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PRELIMINARY GEOLOGIC MAP OF THE GILEAD CREEK AREA, SAGAVANIRKTOK A-2 QUADRANGLE, ARCTIC FOOTHILLS, ALASKA

by

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Sagavanirktok A-2 Quadrangle, Arctic Foothills Alaska

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ELLESMERIAN AND BROOKIAN SEQUENCES

The bedrock in the Gilead Creek area can be subdivided into two megasequences: the Ellesmerian sequence and the Brookian sequence.

The Ellesmerian sequence (Lerand, 1973), was named for a Mississippian to Jurassic age sedimentary succession of rocks in arctic Canada, however, in northern Alaska current usage includes Lower Cretaceous rocks in the Ellesmerian sequence. In northeastern Alaska, Ellesmerian sequence rocks are dominantly a marine clastic and carbonate assemblage. The clastic sequence was derived from a northerly source area and the carbonates formed on a south facing (present day south) carbonate platform. The Ellesmerian sequence in the Gilead Creek area contains the Alapah Limestone and Wahoo Limestone of the Lisburne Group (Mississippian and Pennsylvanian); the Echooka and Ivishak Formations of the Sadlerochit Group (Permian and Triassic); the Shublik Formation (Triassic), and the Kingak Shale (Jurassic-Early Cretaceous).

The Brookian sequence (Lerand, 1973) was named for a Jurassic (?) to Recent age sedimentary assemblage in arctic Canada. In the Gilead Creek area, the Brookian sequence contains a marine clastic succession shed northward; a result of Brooks Range uplift. In the Gilead Creek area rocks of the Brookian sequence include the Gilead Creek sandstone (informal name: Reifenstuhl, 1989; this report) and the Nanushuk Group.

ELLESMERIAN SEQUENCE

Lisburne Group

Schrader (1902) described and named the Lisburne Formation for a thick sequence of light-gray limestone in the Anaktuvuk River area of the central Brooks Range. Later, Leffingwell (1919) referred to similar rocks in northeastern Alaska as the Lisburne Limestone. Detailed work by Bowsher and Dutro (1957) in the Shainin Lake area, subsequently raised the Lisburne Limestone Formation, to Group status and subdivided the rocks into two new formations. The lowermost formation is the Wachsmuth Limestone Formation of Early and Late Mississippian age; this is overlain by the Alapah Limestone Formation of Late Mississippian age. The Alapah Limestone Formation is overlain by the Wahoo Limestone Formation of Early Pennsylvanian age (Brosge and others, 1962).
The Wachsmuth Limestone Formation apparently thins to the northeast and is not recognized in the Gilead Creek area. Regional studies since 1962 indicate that the three Lisburne Group formations (Wachsmuth, Alapah, Wahoo) cannot be readily differentiated on lithologic criteria (Mull, 1989).

The Carboniferous Lisburne Group in northern Alaska formed on an extensive carbonate platform which was later deformed as part of the Brooks Range fold and thrust belt. In the northwestern Arctic National Wildlife Refuge (ANWR), the Lisburne Group is part of the parautochthonous north slope stratigraphy and is less deformed than rocks of the allochthonous Lisburne Group that characterizes most of the central Brooks Range (Mull, 1989; Armstrong and Mamet, 1977, 1978; Wood and Armstrong, 1975). The stratigraphy of the Lisburne Group in the Gilead Creek area is poorly known currently, however it does contain a very distinctive volcanic sequence (Robinson and others, 1989) near the top(?) of the unit that may prove to be a regional marker.

Permian and Triassic Sedimentation

The Lisburne Group is overlain unconformably by quartz arenite, siltstone, and shale, of the Sadlerochit Group. In ascending order, the Sadlerochit Group is composed of the Permian Echooka Formation, Kavik Shale, Ledge Sandstone, and Fire Creek Members of the Triassic Ivishak Formation. The Sadlerochit Group is overlain by phosphate-rich bioclastic rocks of the Shublik Formation (Detterman, 1970, 1974, 1976, 1984; Detterman and others, 1975; Reiser and others, 1971).

Echooka Formation
Good exposures of the Echooka Formation in the Gilead Creek area are limited to stream cuts and hogback outcrops. The Echooka Formation contains two distinctive facies that were differentiated as lithostratigraphic units during our geological mapping: the 'limy facies', and the 'siliceous facies'. The lower(?) limy facies is a succession of bioturbated, fossiliferous, glauconitic and calcareous quartzarenite, sandy limestones, and minor calcareous siltstone. Quartzarenite beds range between 2 cm and 10 cm thick and are separated by intervals of thinly-laminated, glauconitic, red, green, and black shale. At outcrop scale, individual quartz arenite beds are laterally persistent and vary from medium- to thick-bedded and contain disseminated organic matter and concentrations of glauconite and pyrite at various horizons. All of the quartz arenite beds are thoroughly bioturbated and contain no internal primary stratification. Sedimentation rates were apparently fairly low during deposition of the limy facies and *Zoophycus* and other grazing forms were successful at thoroughly reworking sediment and destroying primary sedimentary structures. The contact between the 'limy facies' of the Echooka with the underlying Lisburne Group appears to be either gradational or an unconformity.

An upper(?) 'siliceous facies' map unit of the Echooka recognized in the Gilead Creek area consists of medium dark-gray, fine- to very fine-grained, siliceous, cherty, sandstone and siltstone. This succession is a very siliceous unit in contrast to the limy facies near Rapid Creek. Bedding within sandstone intervals is irregular. Individual beds have convolute tops and bottoms, and they are heavily burrowed. The burrows are vertical and contain a dark-gray finer grained, silty material. The burrows range up to 8 cm long and up to 1 cm in diameter. Sand layers contain abundant spiriferid brachiopods and a few gastropods. Pyrite is abundant and the unit weathers to a distinctive red-brown.

At one locality near the headwaters of Gilead Creek, the contact with the underlying Lisburne Group appears to be a north-dipping, low-angle fault (thrust[?]). The limestone below the fault is highly contorted and folded into a tight, north vergent overturned anticline.

Ivishak Formation, Kavik Shale Member
The Kavik Shale is exposed along the mountain front. Where exposures occur along actively-eroding streams, quartzarenite of the upper Echooka Formation fine rapidly upsection into dark-gray silty shale and minor sandy siltstone or very fine-grained quartz arenite beds characteristic of the Kavik Shale.

Although the grain size difference is small between the upper Echooka and the lower part of the Kavik Shale, the contact between the Kavik Shale and underlying Echooka Formations is abrupt. The internal stratification of the Kavik Member is well-organized whereas the Echooka Formation exhibits slumping or soft-sediment deformation.

Ivishak Formation, Ledge Sandstone Member
The Ledge Sandstone Member in northeastern Alaska has been studied by Keller and others (1961), Detterman and others (1975), Molenaar (1983), McMillen and Colvin (1983), Crowder (in press) and Harun (in press). In the Gilead Creek area, the Ledge Sandstone Member consists of dark-gray to light gray and tan, fine- to very fine-grained, thin- to massive-bedded sandstone with dark-gray and black siltstone interbeds. Sandstone beds range from 1 cm to 40 cm thick and have sharp bottoms and tops and are laterally continuous.

The Ledge Sandstone rests abruptly on interbedded siltstone and quartzarenite beds of the Kavik Shale Member and is the culmination of the general upsection-thickening of sandstone beds. This is the only systematic change in internal organization that exhibits a persistent pattern within the Ledge Sandstone Member.

Ivishak Formation, Fire Creek Member
The Fire Creek Member of the Sadlerochit Group has not been recognized in the Gilead Creek area.

Shublik Formation
The Shublik Formation is a distinctive phosphatic and organic-rich bioclastic limestone and calcareous shale unit with minor quartzarenite and siltstone intervals of Middle to Late Triassic age. The Shublik rests with apparent unconformity on rocks of the Sadlerochit Group throughout the northeast Brooks Range. The composition and organization of the Shublik is significantly unlike the sand-rich rocks of the Sadlerochit Group and records a major change in depositional style. The Shublik has been the subject of a number of stratigraphic and geochemical studies (Tourtelot and Tailleur, 1971; Detterman and others 1975; Seifert and others, 1979; Magoon and Bird 1985; and Parrish 1987).

We recognized four (4) internal lithologic units within the Shublik Formation: 1) The lowest unit is composed of organic-rich siltstone with thin (< 2 cm) fine-grained quartzarenite beds that are laterally continuous at outcrop scale and are often graded and internally plane-parallel to ripple laminated; this lower siltstone unit is abruptly overlain by: 2) Bioclastic limestone containing minor glauconite and conspicuous phosphate nodules ranging to 1 cm in diameter. The limestone contains abundant shells of *Halobia* and *Monotis*, beds are thinly stratified, laterally continuous, and arranged in an upward coarsening and thickening sequence. The bioclastic limestone unit is abruptly overlain by: 3) Organic-rich marl and black mudstone, which grades upsection into:
4) Calcareous siltstone and very fine-grained sandstone at the top of the formation.

Kingak Shale
The Kingak Shale (Jurassic to Neocomian age) underlies the Gilead Creek sandstone in the Gilead Creek area in apparent thrust fault-contact. Open-space fractures with quartz crystals to 1.5 cm long are common. Abundant slickensides, and local brecciation occur at several localities at the top of the unit and suggests that the contact with the overlying Gilead Creek sandstone package is a low-angle fault.
The Kingak Shale consists of black and orange-brown-weathering, soft clay-shale. It is poorly exposed in the map area. Clay ironstone concretions to 15 cm in diameter are abundant throughout the unit. Iron-stained, very-fine-grained sandstone interbeds are also present. No megafossils were found in the Kingak Shale in this study, however, black shale from the top of the Kingak Shale yielded a single poorly preserved specimen of *Pareodinia ceratophora* of probable Jurassic age and suggests a paralic to marginally marine depositional environment (Bujak and Davies, 1989). Two additional palynology samples from the Kingak Shale in the Gilead Creek area have yielded Jurassic, and possible Bathonian (Middle Jurassic) ages. Thermal alteration index (TAI) values in the six samples of the Kingak Shale range from 3 to 4- (Reifenstuhl, 1989).

BROOKIAN SEQUENCE

Gilead Creek sandstone
The 'Gilead Creek sandstone' (informal name) is a 900 m-thick sequence of Lower Cretaceous fine- to medium-grained sandstone, siltstone and shale that crops out south and north of Gilead Creek. In the Gilead Creek area it is part of a faulted, and detached(?) broad southwest-plunging synclinal complex that dominates the foothills northeast of the Ivishak River. Regionally, rocks of the Gilead Creek section crop out along the "Shaviovik front," a northeast-southwest trending salient fold belt of the northeastern Brooks Range mountain front.

Previous work and nomenclature:
Keller and others (1961) mapped the Gilead Creek area and correlated the Gilead Creek sandstone with the lower member of the Ignek Formation. They measured a section (their section # 8) at the same locality as ours (see Reifenstuhl, 1989). No fossils were reported from their measured section.

Lithology:
The Gilead Creek sandstone consists predominantly of sandstone with lesser siltstone and shale. The sandstone is a dark-gray, and medium-gray, dark-gray and orange-brown-weathering, fine- to coarse-grained, subangular, moderately sorted litharenite. The finer grained sandstones range from fine- and very fine-grained sand, to silt. Siltstone is a minor component (< 5 percent) but may be more abundant in rubble- and vegetation-covered zones. Siltstone is a gradational phase between the top of sandstone beds and the overlying thin shale horizons. Shale intervals (typically < 5 cm thick in outcrop) are very dark-gray to black and contain carbonaceous plant fragments and coalified material. The sandstone to shale ratio (ss/sh) is greater than 10/1. Sandstone forms the resistant outcrop ridges in the Gilead Creek area whereas the shale-rich sequences underlie the recessive-weathering, rubble- and vegetation-covered zones. Consequently, sandstone appears to be the dominant rock type in most outcrops.

Matrix and cement in the litharenite consists of < 10 percent clay and iron oxide, however carbonate cement may locally comprise 10 percent of the rock. The carbonate appears to be preferentially concentrated in broadly cross bedded zones. Porosity is estimated to be low in most of the sandstone. Thin section analysis indicate that the sandstone grains consist of: 50% quartz, 30% chert, 10% metamorphic rock fragments, 2% plagioclase feldspar, 2% limonitic-weathered clasts, 1% white mica, and 3% carbonaceous material. In one carbonate-rich section chert grains are replaced by microcrystalline carbonate.

Sedimentology:
The Gilead Creek sandstone is nonchannelized, and typically massive with minor parallel-bedded exposures. Local wavy laminations (upper flow regime ?), hummocky cross stratification, climbing ripples, grading, and trough cross stratification are present. Loadcasts and groove casts are locally abundant. Medium- and coarse-grained sand layers are locally erosive into the underlying, finer grained beds. Zones of carbonate-cemented, medium- and coarse-grained sandstone occur in trough cross stratified beds. The carbonate appears to be preferentially concentrated in these broadly cross bedded zones. Sandstone beds are typically medium-bedded, 1 to 20 cm thick. Resistant thick-bedded units of featureless, medium- and coarse-grained sandstone (> 50 cm thick) are also common. These featureless, massive sandstones appear to be the result of amalgamation rather than bioturbation. Interbeds range from fine- and very fine-grained sandstone to siltstone and shale. The transition from coarse- to fine-grained beds is gradational. In some exposures, 3 cm to 30 cm-thick beds grade from basal, very coarse-grained carbonaceous sand to medium- and fine-grained sand, and then to silt and shale. Bedding-plane parallel laminations, graded bedding and shale rip-ups suggest event-type deposition.

Depositional Environment:
The Gilead Creek sandstone was deposited in a marine setting where nonchannelized, event-type deposition was the dominant sedimentary process. These event-type depositional features and processes bear heavily on any interpretation. Sedimentary structures include: graded bedding, local 1 to 5 cm thick Bouma sequences, flute casts, amalgamation of sandstone beds, and shale rip-ups. However, distinctive climbing ripples and hummocky(?) cross stratification occur. Climbing ripples, in very fine- to coarse-grained sand occur in beds that are typically 3 to 4 cm-thick, but also occur in 15 to 20 cm-thick horizons. Trough cross stratified intervals pinch and swell and range from 20 to 50 cm thick. Individual beds are typically in the 1 to 3 cm range. Climbing ripples and trough cross stratification are commonly attributed to shallow-water environments, rather than classic turbidites, but may also occur in a deep-water, locally channelized environment.

Six coarsening and thickening(?)-up cycles (parasequences) occur within the 900 m measured section of the Gilead Creek sandstone, and range from 100 to 150 m thick. This progradational parasequence set may be analogous to unchannelized sandstone lobe deposits of type I turbidite systems (Mutti, 1985), and represents a lowstand wedge system tract. More definitive details are outstanding.

Regional Correlations:
Possible correlations for the Lower Cretaceous Gilead Creek sandstone include (1) the Albian to Cenomanian Nanushuk Group, (2) the early Albian Torok Formation, (3) early Albian Fortress Mountain Formation, and (4) the early Albian (?) Bathtub Graywacke. Currently we favor a correlation with the Fortress Mountain Formation.

Nanushuk Group
Regionally, the Nanushuk Group of Albian to Cenomanian age is a regressive sequence of marine, transitional, and nonmarine deposits up to 2,750 m thick, exposed in an outcrop belt 30 to 50 km wide and about 650 km long in the Arctic Foothills province, Arctic Slope, Alaska (Huffman, 1989). Well-documented Nanushuk Group rocks cropout 50 km southwest of the map area, in the Marmot syncline at Slope Mountain. Here, more than 1,000 m of section is well exposed, from shale, siltstone, and sandstone at the base, to nonmarine sandstone, siltstone, conglomerate and minor coal at the top. In the Gilead Creek area the Nanushuk Group consists of fine- to very fine-grained, quartzose sandstone, interbedded with sandy siltstone and siltstone, and zones of poorly exposed black shale and mudstone. This sequence appears to represent shallow marine deposition. An extensive outcrop of probable Nanushuk Group occurs along the north side of the Saviukviayak River near its confluence with the Ivishak River. At this location 100 m of dark-gray- to black, clay-shale underlies very-fine- to fine-grained, thin-bedded, flaggy sandstone with interbeds of siltstone and black shale, and common sole marks and cross beds.

STRUCTURAL GEOLOGY
The structural geology of the Gilead Creek area is very complex. The highland areas to the south and southeast are dominated by thrust faults, large north-vergent folds, smaller disharmonic folds, and apparent structural dislocations within the Lisburne Group, Kavik Shale, and Kingak Shale units of the Ellesmerian sequence. The Gilead Creek area is located on the northern margin of the Echooka anticlinorium (informal), one of several large northeast-trending, doubly-plunging, basement-cored anticlinal complexes that form an en echelon succession of asymmetrical folds that extend from the Sagavanirktok River in western ANWR to the Sadlerochit and Shublik Mountains in northern ANWR.

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