PUBLIC-DATA FILE 87-27f

BEDROCK GEOLOGY OF PART OF THE MT. MICHELSON B-3 QUADRANGLE, ARCTIC NATIONAL WILDLIFE REFUGE NORTHEASTERN ALASKA

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Alaska Division of Geological and Geophysical Surveys

December 1987

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GEOLOGIC MAP SYMBOLS


Strike and dip of bedding

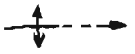

Strike and dip of bedding where stratigraphic top is known

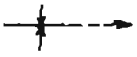

Strike and dip of overturned bedding


Apparent strike and dip of bedding


Horizontal bedding


Strike and dip of cleavage


Strike of the axial trace and plunge of the axis of a large anticline, dashed where approximately located

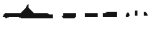

Strike of the axial trace and plunge of the axis of a large syncline, dashed where approximately located


Axial trend of a small anticline


Axial trend of a small syncline

Contact, solid where known, dashed where approximately located, dotted where inferred, queried where questionable


Fault, solid where known, dashed where approximately located, dotted where inferred, queried where questionable


Thrust fault, teeth on upper plate, solid where known, dashed where approximately located, dotted where inferred, queried where questionable

Form lines, trace of bedding

Breccia zones

DESCRIPTION OF MAP UNITS

Shublik Formation

The Shublik Formation forms a distinctive and readily recognizable unit in northern Alaska. In northeastern Alaska, the unit occurs in a narrow belt along the north flank of the Brooks Range and along the Sadlerochit and Shublik Mountains. In structurally complex areas, the Shublik may be missing, or duplicated. In most of northeastern Alaska, the Shublik Formation is divided informally into three members: the basal member is the siltstone member, an overlying limestone and dolomite member, overlain by a clay shale member. The siltstone member is composed predominantly of dark siltstone and calcareous siltstone with a high organic content. The contact with the underlying Fire Creek Siltstone Member of the Ivishak Formation is an unconformity and is marked by a thin but widely distrubuted chert pebble conglomerate horizon that overlies silty shale of the Fire Creek. Calcite may constitutes between 20 and 40 percent of the siltstone locally and is of secondary origin (Detterman et al, 1975). Conformably overlying the basal siltstone member is the limestone and dolomite member that contains many coquinite layers, most of which contain significant amounts of phosphate. Calcite is the dominant component of rocks in this member and constitutes as much as 90 percent of the rock. Secondary dolomite is present and may constitute up to 20 percent of the rock locally. The clay shale member at the top of the formation is predominantly a very fine-grained, silty, calcareous sandstone. The Shublik Formation forms a widespread sequence of rocks that ranges from 100 to 150 meters thick. Locally, structural duplication may account for much thicker sections.

Porosities in the Shublik Formation range from 5 to 30 percent (Jones and Speers, 1976) and total organic carbon contents range from 0.5% to 2%. The formation has fairly good source rock potential and reservoir potential. It has produced gas at the Kemik field and it is part of the main reservoir at Prudhoe Bay.

Trs **Shublik Formation** Thin- to medium-bedded, fine- to medium-grained, calcareous and siliceous, phosphatic, sandstone interbedded with dark, sooty limestones and calcareous siltstone. The unit is very fossiliferous locally and forms subdued outcrops due to its incompetent nature. Horizons that contain abundant phosphate nodules weather a light blue color.

SADLEROCHIT GROUP (Detterman et al, 1975)

Ivishak Formation

The Ivishak Formation (Keller and others, 1961) is the upper-most formation of the Sadlerochit Group in northern Alaska. The contact between the Ivishak and the overlying Shublik Formation is probably a minor unconformity. Fossils from the upper-most Ivishak and the lowest Shublik indicate that there was apparently some local pre-Shublik erosion of the Ivishak section (Detterman et al, 1975).

The Ivishak Formation is broken into three formal members in northeastern Alaska. The Fire Creek Member consists of thin-bedded to massive, argillaceous sandstone siliceous siltstone and minor silty shale. Most of the rocks are cemented by silica, and secondary authigenic calcite has replaced the silica locally (Detterman et al, 1975). Detterman et al (1975) believe that the silica content decreases to the north in the Fire Creek Member. Mud lumps, worm trails and clay ironstone concretions as well as flute and load casts are common in rocks of the Fire Creek Member.

Conformably underlying the the Fire Creek Member is the Ledge Sandstone Member of the Ivishak. The Ledge Sandstone is a resistant, massive sandstone unit that forms prominent hogbacks ridges and questas along the north flank of the Brooks Range and in the Sadlerochit and Shublik Mountains. The Ledge Sandstone Member in outcrop averages from 15 meters thick near Wahoo Lake to as much as 120 meters thick near the Alaska-Canada boundary. Thicker sections are known in the Sadlerochit Mountains (Harun, 1987). The Ledge Sandstone is primarily a clean, massive quartz arenite, that occurs in beds that range from .5 to 3 meters thick. Locally the sandstone is conglomeratic, generally in zones in the upper part of the member. A few thin siltstone and silty shale intervals also occur . Compositionally, the siltstones are

fine-grained versions of the sandstone with a sericitic clay matrix (Detterman et al, 1975). Chert forms between 30 and 40 percent of the rock. Some of the chert is highly weathered (tripolitic). Tripolitic chert grains are characteristic of this member. The composition and sedimentary stuctures indicate a northerly source area and the Ledge Sandstone unit becomes thinner and finer grained to the south. Regional isopachs of the thickness of the Ledge suggest that it may have been deposited in several depositional centers; one at Prudhoe Bay, one north and east of the Sadlerochit Mountains and a third near and to the east of the Alaska-Canada boundary. Thick accumulations of the Ledge Sandstone Member correspond to these depocenters.

Conformably underlying the Ledge Sandstone Member is the Kavik Member of the Ivishak Formation. The Kavik Member is a recessive-weathering unit of silty shale and siltstone, that varies between 15 meters and 75 meters thick in undisturbed section to structurally repeated sections of over 250 meters thick. Lithologically, the Kavik Member consists of thin-bedded, laminated, silty shale, siltstone and minor argillaceous sandstone. Quartz forms about 30 to 40 percent of the rock, generally in well-rounded grains. Most of the sandstone layers are very fine-grained quartz arenites with a clay-rich matrix.

Porosities in the Ivishak range between 2 and 10 percent for surface samples in the ANWR compared to porosities as high as 30 percent for similar units at Prudhoe Bay. Jones and Speers (1976) suggest that the average porosities in the Ivishak may improve northward away from the mountain front. Therefore, there is a high probably that good reservoir quality sandstones occur in the Ivishak Formation.

The Ivishak Formation contains "dead" oil near the Nularvik River in the Sadlerochit Mountains (Gar Pessel, personnel communication, 1985), it has produced gas at the Kavik field, and it contains the main reservoir. at Prudhoe Bay.

lTrfc **Fire Creek Member** Fine- to medium-grained, medium light brown to brown and gray, dark-brown weathering, thin- to massive-bedded, convolute-bedded, quartz-lithic sandstone interbedded with dark-gray to brown very fine-grained siliceous siltstone and minor shale. The sandstone intervals may contain large crossbeds and may represent storm deposits. Shale and siltstone intervals contain abundant mudlumps and show signs of extensive bioturbation. Unit forms a distinctive hump on top of the Ledge Sandstone. The contact between the Fire Creek and the underlying Ledge Sandstone appears to be conformable and gradational.

lTrl **Ledge Sandstone Member** Fine- to medium-grained, light gray to brown, bone to brownish weathering, thin- to massive-bedded, well sorted, mature quartz sandstone. The sandstone contains abundant pyrite locally. The pyrite occurs as blobs to ten mm in diameter and as disseminated concentrations. Layers of poorly sorted, coarse-grained conglomerate occur near the top of the unit. Clasts in the conglomeratic layers range up to 15mm in diameter and are composed of gray and black chert and black shale in a clean quartz sandstone matrix. Unit is thin to massive-bedded and occurs in beds that range from 2 to 30cm thick that are graded locally. Bottoms of some massive beds contain lobate bed forms. Some good porosity is present in the northern exposures in the Sadlerochit Mountains, where the unit contains dead oil. Contact between the Ledge Sandstone and the underlying Kavik Shale is conformable and is marked by a change in overall bedding character and decrease in grainsize of the sandstone. Thickness of the Ledge Sandstone ranges up to 150 meters.

lTrk **Kavik Member** Dark reddish-brown to black and brown, bone weathering, fine- to very-fine grained, thin-laminated, to thin-bedded, and cross stratified, sandy siltstone and shale. Contains spheroidal-weathering sandstone clots locally. Some thin laminated, flaky, black shale occurs near the top of the unit. Contains ripup clasts and pyrite concentrations as blobs and disseminations along bedding surfaces. Often contains brachiopods and crinoid debris and the trace fossil zoophycus(?). Up to 15 meters thick locally.

Echooka Formation

Conformably to disconformably underlying the Kavik Member of the Ivishak Formation is the Echooka Formation (Keller and others, 1961). The Echooka has been subdivided into two members: the upper Iklakpaurak Member and the lower Joe Creek Member. The Iklakpaurak Member consists of a sequence of orthoquartzite, quartzitic sandstone and siltstone that form the main part of the Echooka Formation (Detterman et al, 1975). The sandstones are generally dark, fine-grained quartz arenites. Quartz grains are generally subround to subangular and are cemented by silica that has formed overgrowths. Calcite is a dominant cementing agent locally, and where calcite is the dominant cement, the rocks commonly contain abundant glauconite. Siltstones and shales are essentially fine-grained versions of the quartz arenite with a siliceous clay-rich matrix. The Iklakpaurak Member ranges from less than 10 meters thick to as much as 110 meters thick in the central part of the Sadlerochit Mountians and it thins rapidly to the north.
Underlying the Iklakpaurak Member conformably is the Joe Creek Member, a unit dominated by calcareous siltstone, limy mudstone, chert, and limestone. The calcareous siltstone and limy mudstone are composed of 15 to 30 percent detrital quartz and 15 to 30 percent rounded detrital calcite. Euhedral dolomite grains are present and suggest dolomitization of the unit. The limestones in the upper part of the member are quartz calcarenites and contain 10 to 30 percent detrital quartz. Some of the limestone beds are bioclastic limestone or microcoquinite (Detterman et al, 1975) composed of rounded fragments of brachiopods, bryozoans, corals, gastropods and foraminifera. Glauconite is a common constituent of this unit. The Joe Creek Member ranges from 10 meters to 120 meters thick.

Pe **Echooka Formation Undifferentiated** Unit mapped where the Iklakpaurak Member and the Joe Creek Member are to thin to be represented separately at this map scale.

Pei **Iklakpaurak Member** Interbedded dark-brown, fine-grained quartz arenite and siliceous siltstone. The siltstone contains secondary quartz veining locally. Both calcite and silica are common cementing agents.

Pej **Joe Creek Member** Interbedded brown to dark brown, fine- to coarse-grained, calc arenite and calcareous shale. Contains a glauconitic sandstone and shale interval that forms a resistant ledge above the contact with the underlying Wahoo Limestone. A distinctive orange-weathering horizon at the contact with the Wahoo Limestone is composed of calcareous pebble conglomerate, pebbly lithic sandstone, and glauconitic shale and siltstone. Black chert pebbles are the most common pebbles in the orange-weathering unit, although gray and white chert pebbles also occur. Fossil debris composed of brachiopod, crinoid and coral fragments also form a major component of the orange-weathering unit. Unit commonly channels into the underlying Wahoo Limestone.

LISBURNE GROUP

Schrader (1902) described and named a thick sequence of light gray limestone in the Anaktuvak River area, of the central Brooks Range, the Lisburne Formation. 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 Formation (Limestone) to the Group status and subdivided the rocks into two formations. The lower formation, the Wachsmuth Limestone is of Lower and Upper Mississippian age and the upper formation is the Alapah Limestone is of Upper Mississippian age. The Wachsmuth Limestone apparently thins to the east and northeast and is absent in the map area. In the northeastern Brooks Range, the Alapah Limestone is overlain by the Wahoo Limestone (Brosge and others, 1962) of Late Mississippian to Early Pennsylvanian age (Armstrong and others, 1970). Lisburne Group rocks thicken to the east along strike in the Sadlerochit Mountains and also to the south in the Shublik Mountains.

Pw **Wahoo Limestone** Light-gray to buff and tan, fine- to medium-grained, thin to massive-bedded, interbedded lime mud and bioclastic grainstone. Bedding ranges from a few centimeters to as much as 15 meters thick near the base of the unit. Irregular layers and nodules of gray and black replacement chert are common. It is abundantly fossiliferous, and contains a rich fauna of crinoids, brachiopods and bryozoans. Some tan, thin-laminated dolomitic beds occur locally. Top of the unit is marked by a slight unconformity, on which the orange-weathering unit of the Echooka Formation was deposited. Some channelling on the unconformity surface is present. Where the channels are well exposed, large rip up clasts of limestone are present in the channels.

Mau **upper Alapah Limestone** Light- to medium-gray, thin- to medium-bedded limestone that weathers buff locally. Composed predominantly of lime mudstones that weather into small shard-like irregular pieces. The unit is poorly exposed in the Sadlerochit Mountains and form distinctive talus aprons below the Wahoo Limestone. In the Shublik Mountains the unit is thicker and is represented by dark gray to medium gray, interbedded lime mudstones. The contact between the upper Alapah and the Wahoo Limestone is marked by a massive bed of yellow-brown weathering limestone.

Mal **lower Alapah Limestone** Medium light gray to gray and tan, thin- to massive-bedded limestone that forms a distinctive cliff-forming unit below the upper Alapah Limestone. The contact between the upper Alapah and the lower Alapah unit appears to be gradational. Bedding in the lower unit ranges from less than 1 meter to over 10 meters thick of predominantly pelletoidal packstone and grainstone. Massive bedded pelletoidal grainstones contain large-scale forset crossbeds that are capped by ferruginous interbeds of hematite-stained sands and shales. Some dark gray to green and red shale are also present locally.

Ma **Alapah Limestone** undifferentiated

References Cited

Armstrong, A.K. and Mamet, B.L., 1975, Carboniferous biostratigraphy, northeastern Brooks Range, Arctic Alaska: U.S. Geol. Survey Prof. Paper 884, p. 29.

Armstrong, A.K., Mamet, B.L., and Dutro, J.T., 1970, Foraminiferal zonation and carbonate facies of Carboniferous (Mississippian and Pennsylvanian) Lisburne Group, central and eastern Brooks Range, Arctic Alaska: Am. Assoc. Petroleum Geologists Bull. v. 54, p. 687-698.

Blodgett, R.B., Clough, J.G., Dutro, J.T., Jr., Ormiston, A.R., Palmer, A.R., and Taylor, M.E., 1986, Age revisions of the Nanook Limestone and Katakturuk Dolomite, northeastern Brooks Range, Alaska: In Bartsch-Winkler, S., and Reed, K.M., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1985: U.S. Geological Survey Circular 978, p. 5-10.

Bowsher, A.L., and Dutro, J.T., 1957, The Paleozoic section in the Shainin Lake area, central Brooks Range, northern Alaska: U.S. Geological Survey Prof. Paper 303-A, 39p.

Brosge, W.P., Dutro, J.T. Jr., Mangus, M.D., and Reiser, H.N., 1962, Paleozoic sequence in eastern Brooks Range, Alaska: Am. Assoc. Petroleum Geologists Bull. v. 46, no. 12, p. 2174-2198.

Clough, J.G., 1986, Peritidal sedimentary facies and stromatolites of the Katakturuk Dolomite (Proterozoic), northeastern Alaska [abs]: 12th International Sedimentological Congress, Abstracts, Canberra, Australia, p. 64.

Clough, J.G. and Bakke, Arne, 1986, Measured stratigraphic section of the Lisburne Limestone (85LSB), western Sadlerochit Mountains, Mt. Michelson C-3 Quadrangle, Alaska: Alaska Division of Mining and Geological and Geophysical Surveys Public Data File 86-86h, 1 plate, 9p.

Sadlerochit Mountains, northeastern Brooks Range, Alaska [abs]: Geological Society of America, Cordilleran Section, Abstracts with Programs, p. 367.

Detterman, R.L., Reiser, H.N., Brosge, W.P., and Dutro, J.T. Jr., 1975, Post-Carboniferous stratigraphy of northeaste+rn Alaska: U.S. Geological Survey Professional Paper 886, p.46.

Fackler W.C. (chm., North Slope Stratigraphic Committee), 1971, West to east stratigraphic correlation section Pt. Barrow to Ignek Valley, Arctic North Slope, Alaska: Alaska Geological Society, Anchorage, Alaska.

Gryc, George, and Mangus, M.D., 1947, Preliminary report on the stratigraphy and structure of the Shaviovik and Canning River areas, Alaska: U.S. Geol. Survey Geol. Inv. Naval Petroleum Reserve No. 4, Alaska, open-file report 10.

Jones, H.P., and Speers, R.G., 1976, Permo-Triassic reservoirs of Prudhoe Bay field, North Slope, Alaska: In Braunstein, J. ed., North American oil and gas fields: Am. Assoc. of Petroleum Geologists Memoir 24, p.23-50.

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

Knock, Douglas, 1986, Thirty-seven measure sections of the Kemik Sandstone, Arctic National Wildlife Refuge, northeastern Alaska, Ak. Division of Geological and Geophysical Surveys Public Data File Report 86-86 b.

Leffingwell, E. de K.,1919, The Canning River region, northern Alaska: U.S. Geological Survey Prof. Paper 109, 251 p.

Payne, T.G. and others, 1951, Geology of the Arctic slope of Alaska: U.S. Geol. Survey Oil and Gas Inv. Map OM-126, 3 sheets, scale 1:1,000,000.

Sable, ,1977, Geology of the western Romanzof Mountains, Brooks Range, Alaska: U.S. Geological Survey Professional Paper 897, 84 p.

Schrader, 1902, Geological studies of the Rocky Mountains in northern Alaska: Geological Society of America Bulletin, v. 13, p. 238-252.

Tailleur, I.L., Pessel G.H. and Enwright, S.E., 1978, Subcrop map at Lower Cretaceous unconformity, and maps of Jurassic and Lower Cretaceous seismic horizons, eastern North Slope petroleum province, Alaska: U.S. Geological Survey Misc. Field Studies Map MF-928 I.

Wittington, C.L. and Sable, E.G., 1948, Preliminary Geologic report of the Sadlerochit River area: U.S. Geol. Survey Prelim. Rept. 20, Geol. Inv. Naval Petroleum Reserve No. 4, Alaska open-file report, 18 p.