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Petrographic Survey and Appraisal of Reservoir Quality and Potential, National Petroleum Reserve—Alaska

Thomas C. Mowatt and
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BLM-Alaska Open File Report 36
September 1991

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SUMMARY

As part of the reservoir management, resource assessment, and planning programs of the Bureau of Land Management in Alaska, the oil and gas resource potential of the National Petroleum Reserve in Alaska (NPRA) is undergoing review in light of new technical information, as well as changing national and international socioeconomic conditions. Emphasis in this work has been on integration of geological, petrophysical, geophysical, and engineering information, in order to provide a refined, more technically substantive knowledge base for resource assessment and management.

Petrologic-mineralogic characteristics have been reinvestigated, related to petrophysical parameters and wireline log responses, and integrated with available engineering data, for selected key wells within and peripheral to the NPRA. Particular attention has been directed to diagenetic relationships, effects on reservoir quality, and implications for untested portions of this sizable sedimentary basin. Emphasis has been on clastic rocks, Brookian as well as pre-Brookian. Only some 127 exploratory wells (all but one under government aegis) have been drilled within or adjacent to the NPRA (which is a geographic area on the order of 37,000 square miles–about the size of the state of Indiana). Many of these wells were only drilled to relatively shallow depths.

In almost every well drilled to any appreciable depth in the area, there have been noteworthy manifestations of the presence of hydrocarbons. The results to date might well be interpreted as being rather promising, actually, from a qualitative geological-geochemical perspective, in terms of the potential for significant resources to be present.

INTRODUCTION

The National Petroleum Reserve in Alaska encompasses a large portion of western Alaska, north of the Brooks Range, as shown by *Figure 1*. An appreciable portion of the NPRA is underlain by geologic terranes favorable for occurrences of petroleum resources. This has been recognized for many years (Gryc, 1985). The NPRA must also, of course, be considered in the overall regional context of northern Alaska, and contiguous offshore areas of the Beaufort Sea and the

ERRATA

TUNALIK #1 TEST WELL

10,913'- PEBBLE SHALE. SUBLITHARENITE. VERY FINE SAND. 15-20% VISIBLE POROSITY (APPARENTLY PRINCIPALLY SECONDARY, VIA DISSOLUTION OF CARBONATES, FELDSPARS, LITHIC GRAINS). MODERATELY EFFECTIVE. OIL-STAINED (?).

FAIR-GOOD (?) RESERVOIR QUALITY AS IS. MODERATE POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION (CHERT, CARBONATE -GRAINS AND CEMENT, OTHER LITHIC GRAINS).

WALAKPA #1 TEST WELL

3060'- KINGAK. LITHARENITE. FINE SAND. 10% VISIBLE POROSITY, OF FAIR (OR BETTER?) EFFECTIVENESS.

FAIR RESERVOIR QUALITY AS IS. FAIR-GOOD POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CARBONATE CEMENTS AND GRAINS; CHERT, AND/OR OTHER LITHIC GRAINS).

SOME MINOR CLAYS (AUTHIGENIC-?--CHLORITE??) IN PORES, AS WELL AS THE DEGREE OF COMPACTION TO WHICH THE ROCK HAS BEEN SUBJECTED, ARE NEGATIVE FACTORS, AS IS THE QUARTZ CEMENTATION.

Chukchi Sea. In essence, the area is comprised of the western portion of the North Slope of Alaska. The central portion, to the east, features very large known petroleum resources in the Prudhoe Bay, Kuparuk River, West Sak-Ugnu, etc. fields, while additional resources await further delineation. Farther to the east, in northeastern Alaska, additional significant accumulations of hydrocarbons are known, and inferred.

Thus, the NPRA is, geographically, as well as, more importantly, geologically part of a very significant oil and gas province. Although appreciable work has been done to date, the potential oil and gas resources of the NPRA area remain to be elucidated, by and large. In a very real sense, the area remains relatively untested by the drill. *Figure 2* shows locations of most of the significant wells drilled to date.

GEOLOGIC RELATIONSHIPS

Gryc (1985) summarized the general geological relationships of NPRA as follows: "The present geologic framework of the NPRA is composed of three distinct major physiographic and structural provinces, and comprises three stratigraphic sequences. From north to south, these physiographic provinces are: the Arctic Coastal Plain, the foothills, and the Brooks Range mountain system. These provinces generally reflect the structural elements from north to south: the Barrow arch and the Arctic platform, the Colville basin, and the Brooks Range thrust belt. The stratigraphic sequences within the NPRA subsurface are separated into the Franklinian rocks of pre-Mississippian age, the Ellesmerian rocks of Mississippian to Early Cretaceous age, and the Brookian rocks of Early Cretaceous to Holocene age." *Figure 3*, after Carter, et al (1977), illustrates the general regional stratigraphic relationships.

Regionally, known hydrocarbon resources can be summarized somewhat as follows. Stratigraphic horizons in the Ellesmerian with demonstrated potential are principally the Ivishak Formation of the Sadlerochit Group; the Lisburne Group; the Put River, Sag River, Kingak, and Shublik Formations; the Endicott Group; and the Kuparuk River Formation. The Thomson (Kemik) Sand, as well as the pre-Mississippian "basement" have also shown promise. Brookian sequence horizons with demonstrated production potential include the Nanushuk Group; West Sak and Ugnu sands; Walakpa clastics; and "turbidite" sandstones in the Point Thomson-Flaxman Island area, as well as to the east.

Furthermore, based on existing available information (literature, wireline logs, samples, petrographic thin-sections), strata of potential interest as petroleum reservoirs are not uncommon, areally, as well as

stratigraphically, within and adjacent to the NPRA. Hydrocarbon shows/manifestations are not uncommon in the subsurface, either. Northern Alaska seems to have no dearth of potential hydrocarbon source rocks in the subsurface. Given the relatively scanty drilling density in the region, the oil and gas resources potential has been by no means evaluated sufficiently to permit technically substantive conclusions to be drawn.

CURRENT RESERVOIR QUALITY STUDIES

Petrographic analyses have been carried out of more than four hundred thin-sections, from fifteen wells, presently available to us at the public repository of the Geological Materials Center (GMC), State of Alaska, Eagle River, Alaska. It should be emphasized that our present work deals only with such thin-sections as were available at the GMC.

The thin-sections studied thus far have been principally those from wells drilled by Husky Oil NPR Operations, Inc., under the aegis of the U. S. Geological Survey (USGS), 1977-1982. Some are from wells which predate the Husky-USGS program (U. S. Navy-Husky Petroleum Reserve Number Four programs). Published reports by Husky staff provided much valuable information regarding geologic, petrophysical, and engineering aspects. These reports, dealing with each well drilled by Husky for the USGS are on file at the GMC, as well as a number of other public facilities.

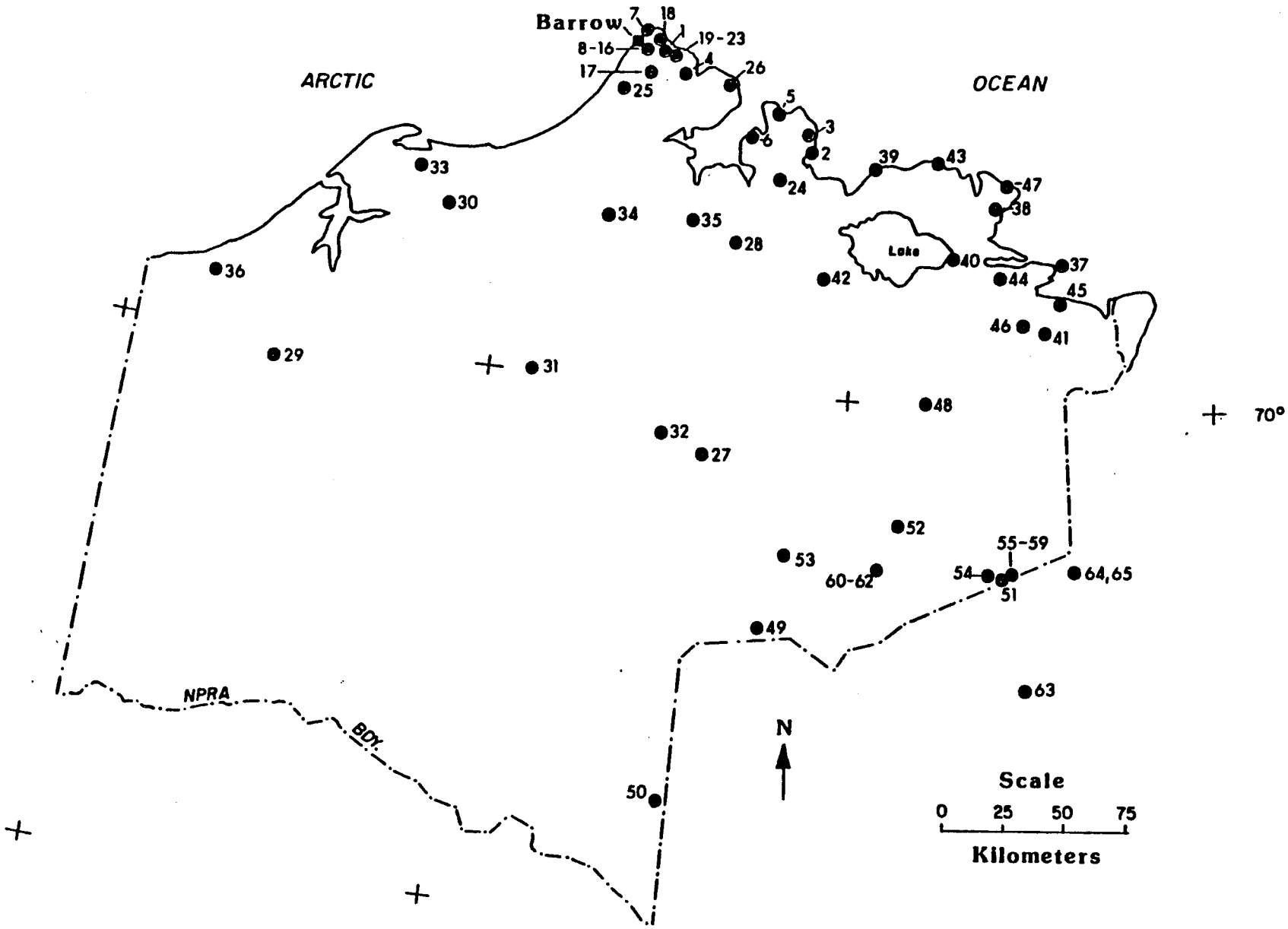
The present report is intended to discuss only some selected aspects–principally the petrography–of our current work, in response to expressed public interest. The comments which follow are merely intended to convey some of the essence of the lithologies and reservoir quality characteristics of some selected horizons of interest, from some selected wells. Our more extensive and complete petrographic descriptions, and related photomicrographs, are being prepared for release in open-file format.

The particular focus here is on reservoir quality considerations. At some risk of perhaps endeavoring to invoke a "Deus ex machina" (Bloch, et al, 1990), it should be noted that secondary dissolution porosity development seems not uncommon in many of the samples studied by us. Admittedly, per the comments of our friend and colleague Dr. Bloch, the proportional contribution to total porosities remains to be rigorously determined, quantitatively, as does its real importance–or lack thereof–relative to hydrocarbon accumulation. This is a key feature of emphasis in our present work. We have been concerned for many years with the presence/absence/origin(s) of discernible secondary dissolution porosity (in the classic sense so well-presented by Schmidt and McDonald, 1979a,b), and its possible role in reservoir quality, as well as potential significance to hydrocarbon

LEGEND FOR FIGURE 2

1. Avak - 1
2. East Simpson - 1
3. East Simpson - 2
4. Iko Bay - 1
5. North Simpson - 1
6. Simpson - 1
7. South Barrow - 1
8. South Barrow - 2
9. South Barrow - 4
10. South Barrow - 6
11. South Barrow - 7
12. South Barrow - 8
13. South Barrow - 9
14. South Barrow - 10
15. South Barrow - 11
16. South Barrow - 13
17. South Barrow - 3
18. South Barrow - 16
19. South Barrow - 12
20. South Barrow - 14
21. South Barrow - 17
22. South Barrow - 19
23. South Barrow - 20
24. South Simpson - 1
25. Walakpa - 1
26. West Dease - 1
27. East Oumalik - 1
*28. East Topagoruk - 1
29. Kaolak - 1
30. Kugrua - 1
*31. Meade - 1
32. Oumalik - 1
33. Peard - 1
34. South Meade - 1
35. Topagoruk - 1
36. Tunalik - 1
37. Atigaru Point - 1
38. Cape Halkett - 1
39. Drew Point - 1
40. East Teshekpuk - 1
*41. Fish Creek - 1
42. Ikpikpuk - 1
43. J.W. Dalton - 1
44. North Kalikpik - 1
45. So. Harrison Bay - 1
46. West Fish Creek - 1
47. W.T. Foran - 1
48. Inigok - 1
*49. Knifeblade - 1, 2A
50. Lisburne - 1
51. Seabee - 1
52. Square Lake - 1
*53. Titaluk - 1
54. Umiat - 1
55. Umiat - 2
56. Umiat - 3
57. Umiat - 4
58. Umiat - 7
59. Umiat - 11
*60. Wolf Creek - 1
*61. Wolf Creek - 2
*62. Wolf Creek - 3
63. Grandstand - 1
64. Gubik - 1
65. Gubik - 2

Figure 2. Locations of wells, NPRA.



Well location, number refers to key on preceding page.

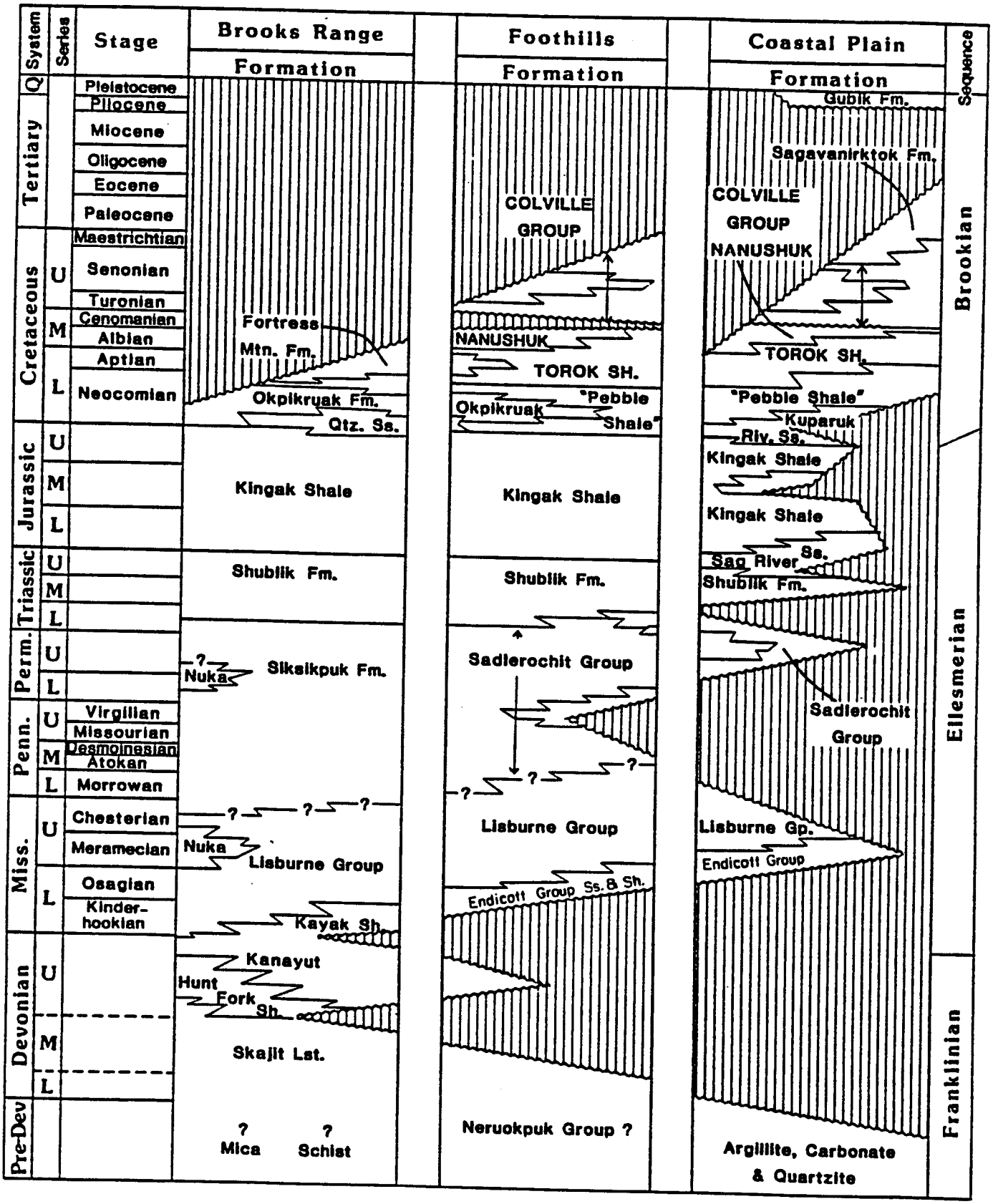


Figure 3. Generalized stratigraphic sections, NPRA (after Carter, et al, 1977).

accumulation in various subsurface environments, particularly northern Alaska (cf. Mowatt and Mowatt, 1990). This is most important, of course, vis-a-vis "prediction" of "potential" reservoir qualities elsewhere, in rocks similar to those from which such prognostications are to be attempted. It is, in one sense, the crux of the matter, in terms of the attempted "assessment" of reservoir potential in the subsurface, prior to testing with the drill. This problem is not restricted to northern Alaska, of course. Future work will present the results of our attempts to inter-relate the petrographic studies with other attributes of the rocks.

SUMMARY COMMENTS, SELECTED HORIZONS, AND KEY WELLS

TUNALIK #1 TEST WELL

81 THIN-SECTIONS FROM THE GMC WERE STUDIED, REPRESENTING MATERIALS OVER THE DEPTH INTERVAL 1650- 17,885 FEET.

17,858'- UPPER LISBURNE. AMYGDALOIDAL BASALT (FLOW).
[THE RESERVOIR QUALITIES DO GET BETTER THAN THIS ROCK!].

17,269-72- UPPER LISBURNE. LITHARENITE-LITHIC WACKE. FINE SAND.
POOR RESERVOIR QUALITY AS IS.
SOME (FAIR OR BETTER) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CHERT AND/OR CARBONATE LITHIC FRAGMENTS, AND/OR CARBONATE CEMENT.

17,135'- UPPER LISBURNE. SILICEOUS LIMESTONE.
POOR RESERVOIR QUALITY, OR POTENTIAL.

15,418.5'- IVISHAK FORMATION. LITHIC WACKE. VERY FINE SAND/SILT SIZE FRAMEWORK GRAINS DOMINANT. POROSITY NIL.
POOR RESERVOIR QUALITY OR POTENTIAL.

12,590'- PEBBLE SHALE. QUARTZ ARENITE. FINE SAND.
5% VISIBLE POROSITY (SECONDARY, AFTER LITHIC GRAINS) TIGHTLY CEMENTED WITH QUARTZ, AS WELL AS LESSER CARBONATE MATERIALS (DOLOMITE; FERROAN CALCITE-REPLACIVE OF DOLOMITE, AT LEAST IN PART).

POOR RESERVOIR QUALITY .
POOR-FAIR? POTENTIAL FOR IMPROVEMENT, VIA CARBONATE DISSOLUTION.

12,585.8'- PEBBLE SHALE. SUBLITHARENITE. FINE SAND.
10-15% VISIBLE POROSITY (BOTH PRIMARY AND SECONDARY?).
OIL-STAINED.
QUARTZ, CARBONATE CEMENTS (INCLUDING DOLOMITE, FERROAN CALCITE).

MODERATE RESERVOIR QUALITY AS IS,
MODERATE POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF CARBONATES.

10,938.75'- PEBBLE SHALE. SUBLITHARENITE. FINE SAND.
10% VISIBLE POROSITY PRINCIPALLY SECONDARY, AFTER VARIOUS LITHIC GRAINS (CHERT. CARBONATES, MICAS, ETC.?). [THERE ARE EXCELLENT EXAMPLES OF THIS HERE].

MODERATE RESERVOIR QUALITY AS IS.
FAIR POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF LITHIC GRAINS, AND/OR CARBONATE CEMENT.

10,936.1'- PEBBLE SHALE. SUBLITHARENITE. BIMODAL: FINE SAND AND COARSE SAND.
5% VISIBLE POROSITY, OF POOR APPARENT EFFECTIVENESS.

POOR RESERVOIR QUALITY AS IS.
POOR POTENTIAL FOR IMPROVEMENT, SINCE THERE ARE NOT SIGNIFICANT LEABILE DISSOLUTION CANDIDATES IN THIS ROCK (JUST SOME CHERT GRAINS, MAINLY IN THE FINE SAND "MATRIX."

10,913'- PEBBLE SHALE. SUBLITHARENITE. VERY FINE SAND.
15-20% VISIBLE POROSITY (APPARENTLY PRINCIPALLY SECONDARY, VIA EFFECTIVE. OIL-STAINED(?).

FAIR -GOOD (?) RESERVOIR QUALITY AS IS.
MODERATE POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION (CHERT, CARBONATE- GRAINS AND CEMENT, OTHER LITHIC GRAINS).

5560.65'- CORWIN/GRANDSTAND. LITHARENITE. FINE SAND.
15-20% VISIBLE POROSITY (MOSTLY PRIMARY, SOME SECONDARY AFTER PLAGIOCLASE, LITHIC GRAINS). GOOD DEGREE OF EFFECTIVENESS.

GOOD RESERVOIR QUALITY AS IS.
FAIR POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION (CHERT GRAINS; CARBONATE GRAINS AND/OR CEMENT; OTHER LITHIC GRAINS.

3288'- CORWIN/GRANDSTAND. LITHARENITE. FINE SAND.
15-20% VISIBLE POROSITY (PRIMARY AND SECONDARY- AFTER LITHIC GRAINS, FELDSPARS). MODERATE-GOOD EFFECTIVENESS.
FAIR-GOOD RESERVOIR QUALITY, WITH FAIR POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF LABILES (CHERT, FELDSPARS).

PEARD #1 TEST WELL

17 THIN-SECTIONS FROM THE GMC WERE STUDIED.

10,225'- PRE-DEVONIAN "ARGILLITE."
SILTSTONE-ARGILLITE.

NIL RESERVOIR QUALITY. ESSENTIALLY ONLY FRACTURE-POROSITY POTENTIAL.

9519'- ECHOOKA. LITHARENITE. FINE SAND.
NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS.
PERHAPS UP TO MODERATE POTENTIAL FOR IMPROVEMENT ELSEWHERE, VIA DISSOLUTION OF LABILES (CARBONATE CEMENT; CHERT GRAINS).

5417.8'- TOROK. LITHARENITE. FINE SAND. 20% VISIBLE POROSITY (PRIMARY-?; SECONDARY- AFTER LITHIC GRAINS, CHERT, PLAGIOCLASE). APPRECIABLE MICRO-POROSITY.

FAIR-GOOD RESERVOIR QUALITY AS IS. FAIR POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF LABILES (CARBONATE CEMENT AND/OR GRAINS; CHERT AND/OR OTHER LITHIC GRAINS; FELDSPARS).

3064-3046.4'-NANUSHUK. LITHARENITE. VERY FINE SAND.
20% VISIBLE POROSITY (PRIMARY; SECONDARY- AFTER PLAGIOCLASE, CHERT, CARBONATE AND OTHER LITHIC GRAINS).

FAIR-GOOD-VERY GOOD(?) RESERVOIR QUALITY AS IS.
FAIR POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF LABILES (CARBONATE GRAINS AND/OR CEMENT; FELDSPAR; OTHER LITHIC GRAINS).

WALAKPA #1 TEST WELL

16 THIN-SECTIONS- ALL OF POOR QUALITY IN TERMS OF PREPARATION- FROM THE GMC WERE STUDIED. THESE SECTIONS REPRESENT MATERIALS FROM THE DEPTH INTERVAL 3659-2063'.

3060'- KINGAK. LITHARENITE. FINE SAND. 10% VISIBLE POROSITY, OF FAIR (OR BETTER?) EFFECTIVENESS.

FAIR RESERVOIR QUALITY AS IS.
FAIR-GOOD POTENTIAL FOR IMPROVEMENT VIA CHERT AND/OR OTHER LITHIC GRAINS).

SOME MINOR CLAYS (AUTHIGENIC ? - CHLORITE ??) IN PORES, AND THE DEGREE OF COMPACTION TO WHICH THE ROCK HAS SUBJECTED ARE NEGATIVE FACTORS, AS IS THE QUARTZ CEMENTATION.

2080'- WALAKPA SANDSTONE. LITHARENITE.
VERY FINE SAND-FINE SAND (WITH LESSER MEDIUM, COARSE, AND VERY-COARSE SAND).

15% VISIBLE POROSITY OF GOOD APPARENT EFFECTIVENESS.

GOOD RESERVOIR QUALITY AS IS. GOOD POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF LABILES (CARBONATE CEMENTS; FELDSPARS; CHERT GRAINS; PERHAPS GLAUCONITE-10% TOTAL IN THIS THIN-SECTION- GRAINS AND CEMENT/PSEUDOMATRIX [?]).

2076'- WALAKPA SANDSTONE. LITHARENITE. VERY FINE-FINE SAND.

20% VISIBLE POROSITY, OF GOOD-VERY GOOD DEGREE OF APPARENT EFFECTIVENESS. MUCH OF THIS SEEMS TO BE SECONDARY HERE.

GOOD-VERY GOOD RESERVOIR QUALITY AS IS.
GOOD POTENTIAL FOR FURTHER IMPROVEMENT VIA DISSOLUTION OF LABILES (FELDSPARS;CHERT AND/OR OTHER LITHIC GRAINS; CARBONATE CEMENT).

2065'- PEBBLE SHALE. LITHARENITE (FINE-MEDIUM SAND) PEBBLE CONGLOMERATE.

15% VISIBLE POROSITY, OF FAIR-GOOD APPARENT EFFECTIVENESS. FAIR-GOOD RESERVOIR QUALITY AS IS. GOOD POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF LABILES (CARBONATE CEMENT; CHERT AND/OR OTHER LITHIC GRAINS).

SOUTH BARROW #15 WELL

5 THIN-SECTIONS FROM THE GMC WERE STUDIED, REPRESENTING MATERIALS FROM THE DEPTH INTERVAL 2184-2121'.

2184'- KINGAK (LOWER BARROW SANDSTONE).
LITHARENITE. FINE (TRACE OF MEDIUM) SAND.

20% VISIBLE POROSITY, OF VERY GOOD APPARENT EFFECTIVENESS.

VERY GOOD RESERVOIR QUALITY AS IS.
MODERATE POTENTIAL FOR FURTHER IIMPROVEMENT VIA DISSOLUTION OF LABILES (CARBONATE CEMENTS; CHERT AND/OR OTHER LITHIC GRAINS).

2165'- KINGAK (UPPER BARROW SANDSTONE).
LITHARENITE. FINE SAND.

10% VISIBLE POROSITY, OF FAIR APPARENT EFFECTIVENESS.
FAIR RESERVOIR QUALITY AS IS.
FAIR POTENTIAL FOR IMPROVEMENT VIA (FURTHER) DISSOLUTION OF LABILES (CHERT GRAINS; PLAGIOCLASE).

NEGATIVE FACTORS ARE CLAYS (MATRIX, PATCHY, 5%), DEGREE OF COMPACTION, QUARTZ CEMENTATION.

WEST DEASE #1 TEST WELL

THIN-SECTIONS FROM THE GMC WERE STUDIED. NONE HAD BEEN PREPARED WITH COLOR-DYED MOUNTING MATERIALS, HENCE ANY POROSITY PRESENT IS NOT EASILY DETERMINED OPTICALLY.

3999.6'- SHUBLIK FORMATION. CONGLOMERATIC LITHARENITE.
SEMI-BIMODAL: FINE SAND AND FINER MATRIX, WITH MEDIUM-SAND TO GRANULE-SIZE MATERIALS.

APPARENTLY OF POOR/NIL RESERVOIR QUALITY AS IS.
PERHAPS FAIR POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CARBONATE FRAGMENTS, AND/OR CEMENT [?]; CHERT, GLAUCONITE GRAINS).

CLAYS IN MATRIX (10%) ARE A NEGATIVE FACTOR.

3954'- SHUBLIK FORMATION. GLAUCONITIC LITHARENITE/ SUBLITHARENITE. MEDIUM/COARSE SAND.

APPARENTLY POOR RESERVOIR QUALITY AS IS. FAIR-GOOD (OR BETTER ?) POTENTIAL FOR IMPROVEMENT VIA DISSOLUTION OF LABILES (CARBONATE CEMENT AND/OR GRAINS; GLAUCONITE, CHERT GRAINS).

3838'- SAG RIVER SANDSTONE. LITHARENITE/LITHIC WACKE (PATCHY MATRIX, 15%). VERY FINE-FINE SAND FRAMEWORK GRAINS.

APPARENTLY POOR RESERVOIR QUALITY AS IS. POOR POTENTIAL FOR IMPROVEMENT, DUE TO VERY FINE GRAIN SIZE, AND MATRIX CLAYS.

PROBABLY A GOOD (OR BETTER ?) SEAL ROCK.

3732.3'- KINGAK (LOWER BARROW SANDSTONE). LITHARENITE/LITHIC WACKE. VERY FINE-FINE SAND SIZE FRAMEWORK GRAINS.

NIL APPARENT RESERVOIR QUALITY AS IS.
POOR POTENTIAL FOR IMPROVEMENT, DUE TO VERY FINE GRAIN SIZE, AND PERVASIVE CLAYS.

PROBABLY A GOOD (OR BETTER ?) SEAL ROCK.

DREW POINT #1 TEST WELL

62 THIN-SECTIONS FROM THE GMC WERE STUDIED. 53 OF THESE ARE FROM THE IVISHAK FORMATION, OVER THE DEPTH INTERVAL OF 7813-7602'. THE OTHER 9 THIN-SECTIONS ARE FROM OTHER SADLEROCHIT/SHUBLIK HORIZONS ABOVE (7601.1-7544').

7812'- IVISHAK FORMATION. LITHARENITE. VERY FINE-FINE (TRACE MEDIUM) SAND.

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS.

POOR-FAIR? POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CARBONATE CEMENT-PATCHY, POIKILOTOPIC; CHERT AND/OR OTHER LITHIC GRAINS.

NEGATIVE FACTORS ARE GRAIN SIZE, QUARTZ CEMENTATION, CLAYS (MATRIX, 5%), DEGREE OF COMPACTION (MODERATE +).

7801'- IVISHAK FORMATION. LITHARENITE. FINE (& VERY FINE) SAND.

5-10% VISIBLE POROSITY, OF POOR APPARENT EFFECTIVENESS.

POOR RESERVOIR QUALITY AS IS.

FAIR POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CARBONATE CEMENT; CHERT AND/OR OTHER LITHIC GRAINS).

NEGATIVE FACTORS ARE GRAIN SIZE, QUARTZ CEMENTATION, CLAYS (MATRIX, 10%).

7721'- IVISHAK FORMATION. LITHARENITE/PEBBLE CONGLOMERATE. <5% VISIBLE POROSITY, OF POOR APPARENT EFFECTIVENESS.

POOR RESERVOIR QUALITY AS IS.

FAIR-GOOD? POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CARBONATE CEMENT; "MATRIX" SAND-SIZE CHERT AND/OR OTHER LITHIC GRAINS; CHERT PEBBLES).

7719'- IVISHAK FORMATION. LITHARENITE. VERY FINE-FINE SAND. <5% VISIBLE POROSITY; PATCHY; SECONDARY, AFTER ARGILLACEOUS LITHIC GRAINS, +/-?. OF POOR-FAIR? APPARENT EFFECTIVENESS

POOR RESERVOIR QUALITY AS IS.

PERHAPS FAIR OR BETTER (?) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION (CONTINUED) OF LITHIC GRAINS, AND/OR CHERT GRAINS; CARBONATE CEMENT.

PERVASIVE QUARTZ CEMENT IS, HOWEVER, A NEGATIVE FACTOR VIS-A-VIS OVERALL RESERVOIR QUALITY POTENTIAL HERE.

7709'- IVISHAK FORMATION. LITHARENITE/ PEBBLE CONGLOMERATE AND. SILTSTONE/SHALE.

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS.

POSSIBLY FAIR-GOOD (?) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CARBONATE CEMENTS; CHERT GRAINS).

HOWEVER, THE FINER-GRAINED PORTIONS/LAYERS OF THIS SPECIMEN LACK THIS DEGREE OF POTENTIAL AND, FURTHER, ON A THIN-SECTION SCALE, WOULD BE NEGATIVE FACTORS IN TERMS OF OVERALL POTENTIAL FOR IMPROVEMENT OF RESERVOIR QUALITY.

IN SUM, OVERALL, THERE MAY BE, AT BEST, A MODERATE (?) POTENTIAL FOR IMPROVEMENT.

7706'- IVISHAK FORMATION. LITHARENITE. COARSE-VERY COARSE SAND.

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS.

FAIR-GOOD, OR BETTER (?) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CARBONATE CEMENTS; CHERT GRAINS).

QUARTZ CEMENTATION IS A NEGATIVE FACTOR.

7622'- IVISHAK FORMATION. LITHARENITE. FINE (-MEDIUM-COARSE) SAND.

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS.

FAIR-GOOD (?) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CARBONATE CEMENTS- ESPECIALLY THE "BEADWORK"; CHERT AND/OR OTHER LITHIC GRAINS.

7600'- IVISHAK?/ SHUBLIK?. SANDY SILTSTONE ADJACENT TO (OVERLYING ?) GRANULE CONGLOMERATE (WEATHERED ?).

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY HERE, AS IS.

PRIOR TO THE APPARENT WEATHERING (?) EFFECTS, THE CONGLOMERATIC MATERIAL MIGHT HAVE HAD FAIR OR BETTER POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CARBONATE CEMENTS; CHERT GRAINS).

PRIOR TO WEATHERING (?) AND INFLUX OF CLAY MATERIALS, ETC., INTO PORE SPACES, THE CONGLOMERATIC MATERIALS MIGHT WELL HAVE HAD GOOD-VERY GOOD RESERVOIR QUALITY.

W. T. FORAN #1 TEST WELL

3 THIN-SECTIONS FROM THE GMC WERE STUDIED. ALL ARE FROM THE KUPARUK SANDSTONE.

7541'- KUPARUK SANDSTONE. LITHARENITE. BIMODAL: VERY FINE-FINE SAND, AND COARSE-VERY COARSE SAND

10% VISIBLE POROSITY, OF GOOD APPARENT EFFECTIVENESS.

GOOD-VERY GOOD (?) RESERVOIR AS IS.

FAIR-GOOD POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CHERT AND/OR OTHER LITHIC GRAINS; CARBONATE CEMENT (WHICH IN ITSELF MAY REPRESENT DISSOLUTION REMNANTS IN THIS SLIDE)).

7539'- KUPARUK SANDSTONE. LITHARENITE. SEMI-BIMODAL: FINE-MEDIUM SAND, AND COARSE-VERY COARSE SAND.

10% VISIBLE POROSITY, OF FAIR APPARENT EFFECTIVENESS.

FAIR RESERVOIR QUALITY AS IS.

FAIR POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CARBONATE CEMENT; CHERT AND/OR OTHER LITHIC GRAINS).

ATIGARU POINT #1 TEST WELL

24 THIN-SECTIONS FROM THE GMC WERE STUDIED. ALL ARE FROM THE IVISHAK FORMATION, OVER THE DEPTH INTERVAL 8741-8712'. FRAMEWORK GRAIN SIZES RANGED FROM VERY FINE TO COARSE SAND.

8741'- IVISHAK FORMATION. LITHARENITE. VERY FINE-FINE SAND.

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS.

FAIR (?) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CARBONATE CEMENT; CHERT GRAINS).

NEGATIVE FACTORS ARE EXTENSIVE QUARTZ CEMENTATION, DEGREE OF COMPACTION, GRAIN SIZE, CLAYS IN PORES.

8731-8730'- IVISHAK FORMATION. LITHARENITE. MEDIUM SAND.

5-8% VISIBLE POROSITY, OF POOR APPARENT EFFECTIVENESS.

POOR RESERVOIR QUALITY AS IS.

POOR-FAIR (?) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CHERT, OTHER LITHIC GRAINS).

NEGATIVE FACTORS ARE QUARTZ CEMENTATION, DEGREE OF COMPACTION.

8718'- IVISHAK FORMATION. LITHARENITE. FINE SAND.

8% VISIBLE POROSITY, OF FAIR (?) APPARENT EFFECTIVENESS.

POOR- FAIR (?) RESERVOIR QUALITY AS IS. FAIR (?) POTENTIA FOR IMPROVEMENT, VIA DISSOLUTION OFLABILES (CHERT, OTHER LITHIC GRAINS).

NEGATIVE FACTORS ARE QUARTZ CEMENTATION, DEGREE OF COMPACTION, GRAIN SIZE, CLAYS-IN PORES.

NOTE: THIS THIN-SECTION SHOWED THE BEST (!) RESERVOIR QUALITY OF THE 24 SECTIONS OF THE IVISHAK AVAILABLE TO US FOR STUDY IN THIS WELL.

8717'- IVISHAK FORMATION. LITHARENITE. FINE SAND.

5% VISIBLE POROSITY, OF VERY POOR APPARENT EFFECTIVENESS (ESSENTIALLY NIL).

VERY POOR RESERVOIR QUALITY AS IS.

POOR POTENTIAL FOR IMPROVEMENT (VIA DISSOLUTION OF CHERT AND/OR OTHER LITHIC GRAINS), DUE TO QUARTZ CEMENTATION, DEGREE OF COMPACTION, GRAIN SIZE AND CLAYS- IN PORES.

BUT, NOTE: THERE IS, NOW, SOME SECONDARY POROSITY PRESENT, EVEN IN THIS "TIGHT" ROCK, WITHIN SOME OF HE CHERT AND OTHER LITHIC GRAINS.

8712'- IVISHAK FORMATION. LITHARENITE. FINE SAND.

5-8% VISIBLE POROSITY, OF POOR-FAIR (?) APPARENT EFFECTIVENESS.

POOR-FAIR (?) RESERVOIR QUALITY AS IS.

FAIR (?) POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILES (CHERT AND/OR OTHER LITHIC GRAINS; TRACES OF CARBONATE CEMENT, GRAINS).

NEGATIVE FACTORS ARE QUARTZ CEMENTATION, DEGREE OF COMPACTION, GRAIN SIZE, CLAYS-IN PORES.

INIGOK #1 TEST WELL

24 THIN-SECTIONS FROM THE GMC WERE STUDIED.

15,215'- LISBURNE GROUP. BIOCLASTIC GRAINSTONE/PACKSTONE.

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS

POTENTIAL FOR IMPROVEMENT THAT OF ANY SUCH CARBONATE ROCK, VIA DISSOLUTION AND/OR FRACTURING.

14,060-14,062'- LISBURNE GROUP. OOLITIC-BIOCLASTIC WACKESTONE AND INTERBEDDED SILTSTONE.

NIL VISIBLE POROSITY.

NIL RESERVOIR QUALITY AS IS.

POTENTIAL FOR IMPROVEMENT THAT OF ANY SUCH CARBONATE ROCK, VIA DISSOLUTION AND/OR FRACTURING.

THE INTERBEDDED SILTSTONE IS A DECIDED NEGATIVE FACTOR IN TERMS OF OVERALL POTENTIAL, OF COURSE.

8851 AND 8212.9'- TOROK FORMATION. LITHARENITES. FINE SANDS.

NIL-TRACE VISIBLE POROSITY.

PERHAPS FAIR (OR BETTER ?) POTENTIAL FOR IMPROVEMENT ELSEWHERE, VIA DISSOLUTION OF LABILE CONSTITUENTS (CHERT AND CARBONATE GRAINS, FELDSPARS).

3081.9 (-3077.5)'- NANUSHUK GROUP. LITHARENITES. VERY FINE, FINE, AND FINE-COARSE SANDS.

10-30% VISIBLE POROSITIES (PRIMARY; AND SECONDARY, AFTER CHERT, OTHER LITHIC GRAINS, FELDSPARS).

FAIR-VERY GOOD RESERVOIR QUALITY AS IS.

FAIR-GOOD POTENTIAL FOR IMPROVEMENT, VIA DISSOLUTION OF LABILE CONSTITUENTS (CHERT, FELDSPARS, CARBONATE AND OTHER LITHIC GRAINS).

2636.5'- NANUSHUK GROUP. LITHARENITE. VERY FINE SAND.

25-30% VISIBLE POROSITY (PRIMARY; AND SECONDARY, AFTER LITHIC GRAINS).

VERY GOOD RESERVOIR QUALITY, LOCALLY, AS IS, ALTHOUGH ASSOCIATED CLAY-RICH HORIZONS MAY WELL MILITATE AGAINST EFFECTIVENESS OF POROSITY ON A LARGER SCALE.

FAIR POTENTIAL FOR IMPROVEMENT OF POROSITY VIA DISSOLUTION OF LABILE CONSTITUENTS (CHERT, CARBONATE, AND OTHER LITHIC GRAINS, FELDSPARS).

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