

North Aleutian Basin Play 5: Mesozoic Deformed Sedimentary Rocks (Triassic-Cretaceous)

Geological Assessment

GRASP UAI: AAAAA HAF

Play Area: 5,040 square miles

Play Water Depth Range: 15-700 feet

Play Depth Range: 2,000-15,000 feet

Play Exploration Chance: 0.09216

Play 5, Mesozoic Deformed Sedimentary Rocks (Triassic-Cretaceous), North Aleutian Basin OCS Planning Area, 2006 Assessment, Undiscovered Technically-Recoverable Oil & Gas			
Assessment Results as of November 2005			
Resource Commodity (Units)	Resources *		
	F95	Mean	F05
BOE (Mmboe)	0	41	197
Total Gas (Tcfg)	0.000	0.017	0.079
Total Liquids (Mmbo)	0	38	183
Free Gas** (Tcfg)	0.000	0.000	0.000
Solution Gas (Tcfg)	0.000	0.017	0.079
Oil (Mmbo)	0	38	183
Condensate (Mmbc)	0	0	0
<i>* Risked, Technically-Recoverable</i> <i>** Free Gas Includes Gas Cap and Non-Associated Gas</i> <i>F95 = 95% chance that resources will equal or exceed the given quantity</i> <i>F05 = 5% chance that resources will equal or exceed the given quantity</i> <i>BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas</i> <i>Mmb = millions of barrels</i> <i>Tcf = trillions of cubic feet</i>			

Table 1

Play 5, the “Mesozoic Deformed Sedimentary Rocks” play, contributes a mere 1.8% (41 Mmboe) of the energy endowment (2,287 Mmboe) of the North Aleutian Basin OCS Planning Area. The overall assessment results for play 5 are shown in [table 1](#). Oil forms 93% of the energy endowment of play 5. [Table 5](#)

reports the detailed assessment results by commodity for play 5.

[Table 3](#) summarizes the volumetric input data developed for the *GRASP* computer model of North Aleutian basin play 5. [Table 4](#) reports the risk model used for play 5. The location of play 5 is shown in [figure 1](#).

Folded and thrust-faulted Mesozoic sedimentary rocks are widely exposed on the south side of the Alaska Peninsula. Exploration drilling on the Alaska Peninsula began in 1903 with drilling on oil seeps along the axes of anticlines near the east end of Becharof Lake. Oil seep drilling continued through 1940 and ultimately 10 wells were drilled. Five modern (1961-1981) wells (Canoe Bay 1, Big River 1, Koniag 1, Painter Creek 1, and Wide Bay 1) also tested exposed fold structures along the south flank of the Alaska Peninsula. On the north flank of the Alaska Peninsula and along the southern edge of North Aleutian basin, Mesozoic sedimentary rocks were penetrated by 3 wells (Cathedral River 1, David River 1/1A, and Hoodoo Lake 2 wells). To the west, five wells in St. George basin (St. George COST 2, Rat 1, Segula 1, Tustamena 1 [Y-0530], and Tustamena 2 [Y-0527] wells) reached total depth in Jurassic rocks. The North Aleutian Shelf COST 1 well did not penetrate Mesozoic rocks. The principal point of well information for the Mesozoic rocks of play 5 is the Cathedral River 1 well atop the onshore extension of the Black Hills uplift. The Cathedral River 1 well penetrated a relatively complete Mesozoic sequence 13,911 feet thick and ranging in age from Late Triassic (Kamishak Fm.) to Late Jurassic (Naknek Fm.).

No significant pools of oil or gas were encountered in any of the wells testing Mesozoic rocks on the Alaska Peninsula or in St. George basin. The Humble Bear Creek 1 well near Becharof Lake recovered 450 Mcf/d of gas and large amounts (5,800 feet in drill pipe) of salt water from a 120-foot interval of the uppermost part of the Talkeetna Formation. Elsewhere, several wells encountered sparse oil and gas shows in Mesozoic rocks correlative to the play 5 sequence. Oil shows generally consist of white to yellow sample fluorescence and weak to streaming white, blue, or yellow cut fluorescence from isolated pores or fractures in impermeable sandstones and siltstones. In the Cathedral River 1 well, oil shows were encountered as shallow as 390 feet and were commonly observed down to 7,500 feet. At 7,500 feet, a petroleum-based mud additive (Soltex©) was introduced to the drilling mud, casting suspicion on the authenticity of the widespread hydrocarbon shows observed at greater depths. Flow tests in the Shelikof and Kialagvik Formations (Middle Jurassic) and the Talkeetna Formation (Lower Jurassic) in the Cathedral River 1 well recovered gassy drilling mud with traces of oil. In northern Cook Inlet, some oil production (<300,000 barrels) has occurred from fractured Talkeetna Formation beneath the principal accumulation (in Tertiary rocks) in the McArthur River field.

Across the eastern Alaska Peninsula and western Alaska Range, the Bruin Bay fault forms the contact between a Mesozoic volcano-plutonic arc terrane on the north and a Mesozoic sedimentary basin on the south. The Bruin Bay fault is extrapolated offshore beneath the North Aleutian basin as the boundary between a northern area of high-frequency, high-amplitude magnetic anomalies and a southern area of low-

frequency, low-amplitude magnetic anomalies. We speculate that the magnetic anomaly field north of the projected Bruin Bay fault corresponds to the volcano-plutonic arc terrane exposed north of the Bruin Bay fault onshore. These rocks were penetrated beneath Tertiary strata in three wells (Great Basins 1, Great Basins 2, and Becharof Lake 1 wells) in the northeast part of North Aleutian basin. The magnetic anomaly field south of the projected Bruin Bay fault represents an offshore extension of the deformed Mesozoic sedimentary rocks of the Alaska Peninsula, as demonstrated by penetrations of Mesozoic rocks at several wells to the west in St. George basin and at the Cathedral River 1, David River 1/1A, and Hoodoo Lake 2 wells on the Alaska Peninsula. The area of play 5 corresponds to the area of the low-frequency, low-amplitude magnetic field south of the offshore extension of the Bruin Bay fault, and underlies the Amak basin and the Black Hills uplift.

Most of the oil and gas resources of play 5 are associated with hypothetical pools of oil captured in anticlines or fault traps like those exposed on the Alaska Peninsula. We have not mapped such structures within the Mesozoic complex offshore, but fold, thrust-fault, and wrench-fault structures are observed in available seismic data. The surface anticlines outlined by geologic mapping near Becharof Lake range from 7,000 to 147,000 acres in gross map area and the ranges of sizes of these anticlines were used to model hypothetical prospect areas in play 5. Potential reservoir formations in play 5 include the Lower Jurassic Talkeetna Formation, the Upper Jurassic Naknek Formation, the Lower Cretaceous Staniukovich and Herendeen Formations, and the Upper Cretaceous Chignik and/or Hoodoo Formations. In outcrop and well penetrations, most of these

sandstones and conglomerates are highly zeolitized and preserve negligible porosity. The Staniukovich and Naknek Formations generally have the smallest fractions of volcanoclastic detritus, and, as the younger (or shallower) reservoir formations in the Mesozoic assemblage, have a burial history that is less severe than that of Middle Jurassic and older units.

The principal resource in play 5 is predicted to be oil with no accumulations of free gas. Play 5 was modeled as an oil play because it is assumed to be charged by Middle Jurassic oil sources like those that charged the undersaturated (relative to gas) oil fields of northern Cook Inlet. Play 5 includes strata that are age-equivalent to known regional oil source beds of Middle Jurassic (Kialagvik Fm. or Tuxedni Gp.) and Late Triassic (Kamishak Fm.) ages. The Middle Jurassic Tuxedni Group is the source for 1.6 billion barrels of original oil reserves in northern Cook Inlet, most of which are pooled in Tertiary-age rocks that overlie the Tuxedni Group. The Tuxedni-correlative sequence on the Alaska Peninsula—the Kialagvik Formation—is present in the Cathedral River 1 well onshore. Geochemical anomalies associated with the Kialagvik Formation in the Cathedral River 1 well may suggest a past role as an oil source. In the Cathedral River 1 well, oil shows were widely observed in the rocks overlying the Kialagvik Formation, which is thermally overmature ($TAI = 3.0$ to 3.8) and post oil-generative. It is probable that Mesozoic oil sources in this area generated and expelled the oil in a past (pre-Tertiary) cycle of deep burial and thermal transformation of organic matter. The existence of viable oil accumulations in play 5 requires that the generation of oil out of these source rocks predate zeolitization of pore systems in Mesozoic sandstone reservoirs. Unfortunately, the general case appears to

be that oil generation and migration followed reservoir zeolitization. Oil, though commonly observed in Mesozoic rocks in wells and outcrops, is only observed in trace quantities in fractures or in isolated pores that survived zeolitization.

Four major risk factors for play 5 relate to:

1) reservoir (early zeolitization and porosity destruction in chemically reactive volcanoclastic sandstones); **2) timing** (oil generation and migration must occur early [Late Jurassic or Early Cretaceous] to protect reservoir pore systems, but traps probably did not form until Late Cretaceous or early Cenozoic time); **3) trap integrity** (breaching of traps at Miocene and older Cenozoic unconformities or trap disruption by faults may have destroyed Mesozoic petroleum accumulations); and **4) preservation** (exhumation to shallow burial depths and invasion of meteoric waters may have promoted biological degradation of oil in Mesozoic-age accumulations to asphaltic materials).

A maximum of 13 hypothetical pools is forecast by the aggregation of the risk model and the prospect numbers model for play 5. These pools range in mean conditional (un-risked) recoverable volumes from 2 Mmboe (pool rank 13) to 63 Mmboe (pool rank 1). Pool rank 1 ranges in possible conditional recoverable volumes from 8 Mmboe (F95) to 176 Mmboe (F05), or, in the case of gas, from 0.04 Tcfge (F95) to 0.99 Tcfge (F05). [Table 2](#) shows the conditional sizes of the 10 largest pools in play 5.

Play 5, Mesozoic Deformed Sedimentary Rocks, North Aleutian Basin OCS Planning Area, 2006 Assessment, Conditional BOE Sizes of Ten Largest Pools			
Assessment Results as of November 2005			
Pool Rank	BOE Resources *		
	F95	Mean	F05
1	8	63	176
2	3	26	70
3	1.5	15	41
4	1.0	10	27
5	0.7	7	20
6	0.6	6	15
7	0.51	5	13
8	0.43	3.9	11
9	0.36	3.4	9
10	0.31	3.0	8
<p>* Conditional, Technically-Recoverable, Millions of Barrels Energy-Equivalent (Mmboe), from "PSRK.out" file</p> <p>F95 = 95% chance that resources will equal or exceed the given quantity</p> <p>F05 = 5% chance that resources will equal or exceed the given quantity</p> <p>BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas</p>			

Table 2

In the computer simulation for play 5, a total of 14,327 “simulation pools” were sampled for size. These simulation pools can be grouped according to the USGS size class system in which sizes double with each successive class. Pool size class 10 contains the largest share (3,088, or 22%) of simulation pools (conditional, technically recoverable BOE resources) for play 5. Pool size class 10 ranges from 16 to 32 Mmboe. The largest pool among the 14,327 simulation pools falls within pool size class 16, which ranges in size from 1,024 to 2,048 Mmboe. [Table 6](#) reports statistics for the simulation pools developed in the *GRASP* computer model for play 5.

GRASP Play Data Form (Minerals Management Service-Alaska Regional Office)

Basin: North Aleutian Basin
 Play Number: 5
 Play UAI Number: AAAAA HAF

Assessor(s): K.W. Sherwood, D. Comer, J. Larson
 Play Name: Mesozoic Deformed Sedimentary Rocks (Triassic-Cretaceous)

Date: December 2004

Play Area: 5,040 mi² (3.2 million acres)
 Reservoir Thermal Maturity: 0.6% to 2.0% Ro

Play Depth Range: 2,000 to 15,000 feet (mean = 8,000 ft)
 Expected Oil Gravity: 35° API
 Play Water Depth Range: 15-700 feet (mean = 350 ft)

POOLS Module (Volumes of Pools, Acre-Feet)

Fractile	F100	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Prospect Area (acres)-Model Input*	7000		10415		39621	68223/95634			150718				147000
Prospect Area (acres)-Model Output**	1024	6793	9768	18402	35028	44767/33824	63167	82991	97444	116497	120000	125000	146550
Fill Fraction (Fraction of Area Filled)	0.03	0.05	0.06	0.08	0.1	0.11/0.05	0.13	0.16	0.17	0.2	0.23	0.25	0.5
Productive Area of Pool (acres)	93	595	902	1736	3478	5004/4766	6596	9087	10687	13683	17000	19000	43443
Pay Thickness (feet)	18	47	55	73	100	113/60	137	162	182	215	260	295	564

* model fit to prospect area data in *BESTFIT*

** output from @RISK after aggregation with fill fraction

MPRO Module (Numbers of Pools)

Input Play Level Chance	0.4
Output Play Level Chance*	0.3922

Prospect Level Chance	0.2304
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Exploration Chance	0.09216
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* First Occurrence of Non Zero Pools As Reported in PSUM Module

Risk Model	Play Chance	Petroleum System Factors	Prospect Chance
	0.5	Reservoir (widespread early zeolitization)	0.6
	0.8	Timing of migration (if early, no traps; if late, no porosity)	0.6
		Trap integrity (erosional breaching and fault disruption)	0.8
		Preservation (denudation to shallow depths/biodegradation of petroleum accumulations in Mesozoic rocks)	0.8

Fractile	F99	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Numbers of Prospects in Play	11	12	13	14	15	15.56/1.76	16	17	17.5	18	18.5	19	22
Numbers of Pools in Play						1.43/2.06	3	4	5	6	7	7	13

Zero Pools at F39.25

Minimum Number of Pools	2 (F35)	Mean Number of Pools	1.43	Maximum Number of Pools	13
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POOLS/PSRK/PSUM Modules (Play Resources)

Fractile	F100	F95	F90	F75	F50	Mean/Std. Dev.	F25	F15	F10	F05	F02	F01	F00
Oil Recovery Factor (bbl/acre-foot)	1	17	21	30	43	47/25	59	69	77	89	105	120	218
Gas Recovery Factor (Mcfg/acre-foot)	No Free Gas												
Gas Oil Ratio (Sol'n Gas)(cf/bbl)	56	162	195	267	376	426/220	531	638	723	871	1073	1100	1110
Condensate Yield (bbl/Mmcfg)	No Free Gas												

Pool Size Distribution Statistics from *POOLS* (1,000 BOE): μ (mu)= 9.564 σ^2 (sigma squared)= 1.609 Random Number Generator Seed= 458,844

BOE Conversion Factor (cf/bbl)	5620	Probability Any Pool Contains Both Oil and Free Gas (Gas Cap)	0
Probability Any Pool is 100% Oil	1	Fraction of Pool Volume Gas-Bearing in Oil Pools with Gas Cap	0
Probability Any Pool is 100% Gas	0		

Table 3. Input data for North Aleutian basin play 5, 2006 assessment.

GRASP - Geologic and Economic Resource Assessment Model - PSUM Module Results

Minerals Management Service - Alaska OCS Region

GRASP Model Version: 8.29.2005)

Computes the Geologic Resource Potential of the Play

Play UAI: AAAAAHAF		Play No. 5	
World	Level -	World	Level Resources
Country	Level -	UNITED STATES	OF AMERICA
Region	Level -	MMS	ALASKA REGION
Basin	Level -	NORTH ALEUTIAN	BASIN
Play	Level -	Play	5 Mesozoic - Deformed Sedimentary Rocks (Chignik Terrane)
Geologist	Sherwood		
Remarks	2005 A		
Run Date & Time:	Date	19-Sep-05 Time	14:08:12

Summary of Play Potential

Product	MEAN	Standard Deviation
BOE (Mboe)	41,126	78,062
Oil (Mbo)	38,180	72,371
Condensate (Mbc)	0	0
Free (Gas Cap & Nonassociated) Gas (Mmcfg)	0	0
Solution Gas (Mmcfg)	16,552	34,073

10000 (Number of Trials in Sample)

0.3922 (MPhc [Probability] of First Occurrence of Non-Zero Resource)

Windowing Feature: used

Empirical Probability Distributions of the Products

Greater Than Percentage	BOE (Mboe)	Oil (Mbo)	Condensate (Mbc)	Free (Gas Cap & Nonassociated) Gas (Mmcfg)	Solution Gas (Mmcfg)
100	0	0	0	0	0
99.99	0	0	0	0	0
99	0	0	0	0	0
95	0	0	0	0	0
90	0	0	0	0	0
85	0	0	0	0	0
80	0	0	0	0	0
75	0	0	0	0	0
70	0	0	0	0	0
65	0	0	0	0	0
60	0	0	0	0	0
55	0	0	0	0	0
50	0	0	0	0	0
45	0	0	0	0	0
40	0	0	0	0	0
35	20,641	19,283	0	0	7,635
30	38,998	36,298	0	0	15,174
25	58,286	54,188	0	0	23,034
20	78,594	73,135	0	0	30,679
15	103,520	96,238	0	0	40,911
10	141,430	131,390	0	0	56,438
8	159,800	147,770	0	0	67,609
6	182,460	169,970	0	0	70,226
5	196,810	182,790	0	0	78,814
4	213,740	198,270	0	0	86,907
2	274,320	253,520	0	0	116,890
1	343,150	317,810	0	0	142,420
0.1	585,680	541,500	0	0	248,240
0.01	769,070	676,290	0	0	521,400
0.001	1,719,100	1,608,900	0	0	619,300

Table 5. Assessment results by commodity for North Aleutian basin play 5, 2006 assessment.

Basin: NORTH ALEUTIAN BASIN Play 5 - Mesozoic - Deformed Sedimentary Rocks UAI Key: AAAAAHAF							Model Simulation "Pools" Reported by "Fieldsize.out" GRASP Module																		
Classification and Size				Pool Count Statistics			Pool Types Count			Mixed Pool Range		Oil Pool Range		Gas Pool Range		Total Pool Range		Pool Resource Statistics (MMBOE)							
Class	Min (MMBOE)	Max (MMBOE)	Pool Count	Percentage	Trial Average	Trials w/Pool Avg	Mixed Pool	Oil Pool	Gas Pool	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Total Resource	Average Resource				
1	0.0312	0.0625	5	0.034899	0.0005	0.001275	0	5	0	0	0	1	1	0	0	0	1	1	0.033613	0.052883	0.196259	39.251834			
2	0.0625	0.125	7	0.048859	0.0007	0.001784	0	7	0	0	0	1	1	0	0	0	1	1	0.062570	0.124975	0.656652	93.807414			
3	0.125	0.25	32	0.223355	0.0032	0.008157	0	32	0	0	0	1	1	0	0	0	1	1	0.130025	0.246364	5.939180	185.599372			
4	0.25	0.5	101	0.704963	0.0101	0.025746	0	101	0	0	0	1	2	0	0	0	1	2	0.251494	0.498746	38.643964	382.613510			
5	0.5	1	278	1.940392	0.0278	0.070864	0	278	0	0	0	1	2	0	0	0	1	2	0.500137	0.999363	212.849251	765.644789			
6	1	2	570	3.978502	0.057	0.145297	0	570	0	0	0	1	3	0	0	0	1	3	1.000484	1.995872	864.145204	1.516044			
7	2	4	1201	8.382773	0.1201	0.306143	0	1201	0	0	0	1	3	0	0	0	1	3	2.000338	3.996681	3612.659000	3.008043			
8	4	8	2164	15.104348	0.2164	0.551619	0	2164	0	0	0	1	4	0	0	0	1	4	4.000210	7.999863	12886.266000	5.954836			
9	8	16	2948	20.576534	0.2948	0.751466	0	2948	0	0	0	1	6	0	0	0	1	6	8.000044	15.990325	34383.653000	11.663383			
10	16	32	3088	21.553709	0.3088	0.787153	0	3088	0	0	0	1	6	0	0	0	1	6	16.008136	31.998237	70958.909000	22.978922			
11	32	64	2387	16.660851	0.2387	0.608463	0	2387	0	0	0	1	4	0	0	0	1	4	32.009468	63.973127	107260.469000	44.935261			
12	64	128	1166	8.13848	0.1166	0.297222	0	1166	0	0	0	1	4	0	0	0	1	4	64.058941	127.861662	101526.334000	87.072327			
13	128	256	304	2.121868	0.0304	0.077492	0	304	0	0	0	1	2	0	0	0	1	2	128.212729	255.447400	51115.172000	168.142014			
14	256	512	66	0.460669	0.0066	0.016824	0	66	0	0	0	1	1	0	0	0	1	1	256.377009	500.417259	21784.025000	330.060974			
15	512	1024	8	0.055839	0.0008	0.002039	0	8	0	0	0	1	1	0	0	0	1	1	516.614952	674.174098	4888.902000	611.112732			
16	1024	2048	1	0.00698	0.0001	0.000255	0	1	0	0	0	1	1	0	0	0	1	1	1716.935000	1716.935000	1716.935000	1.716935			
17	2048	4096	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
18	4096	8192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
19	8192	16384	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
20	16384	32768	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
21	32768	65536	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
22	65536	131072	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
23	131072	262144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
24	262144	524288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
25	524288	1048576	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000000	0.000000	0.000000	0.000000			
Not Classified			1	0.00698	0.0001	0.000255	Below Class	0	1	0	Below Class											0.030240	0.030240	0.030240	30.239845
Totals			14327	100	1.4327	3.652052	Above Class	0	0	0	Above Class											0.000000	0.000000	0.000000	0.000000
Number of Pools not Classified: 1							Min and Max refer to numbers of pools of the relevant size class that occur within any single trial in the simulation.																		
Number of Pools below Class 1: 1							Min and Max refer to aggregate resources of the relevant size class that occur within any single trial in the simulation.																		
Number of Trials with Pools: 3923																									

Table 6. Statistics for simulation pools created in computer sampling run for North Aleutian basin play 5, 2006 assessment.

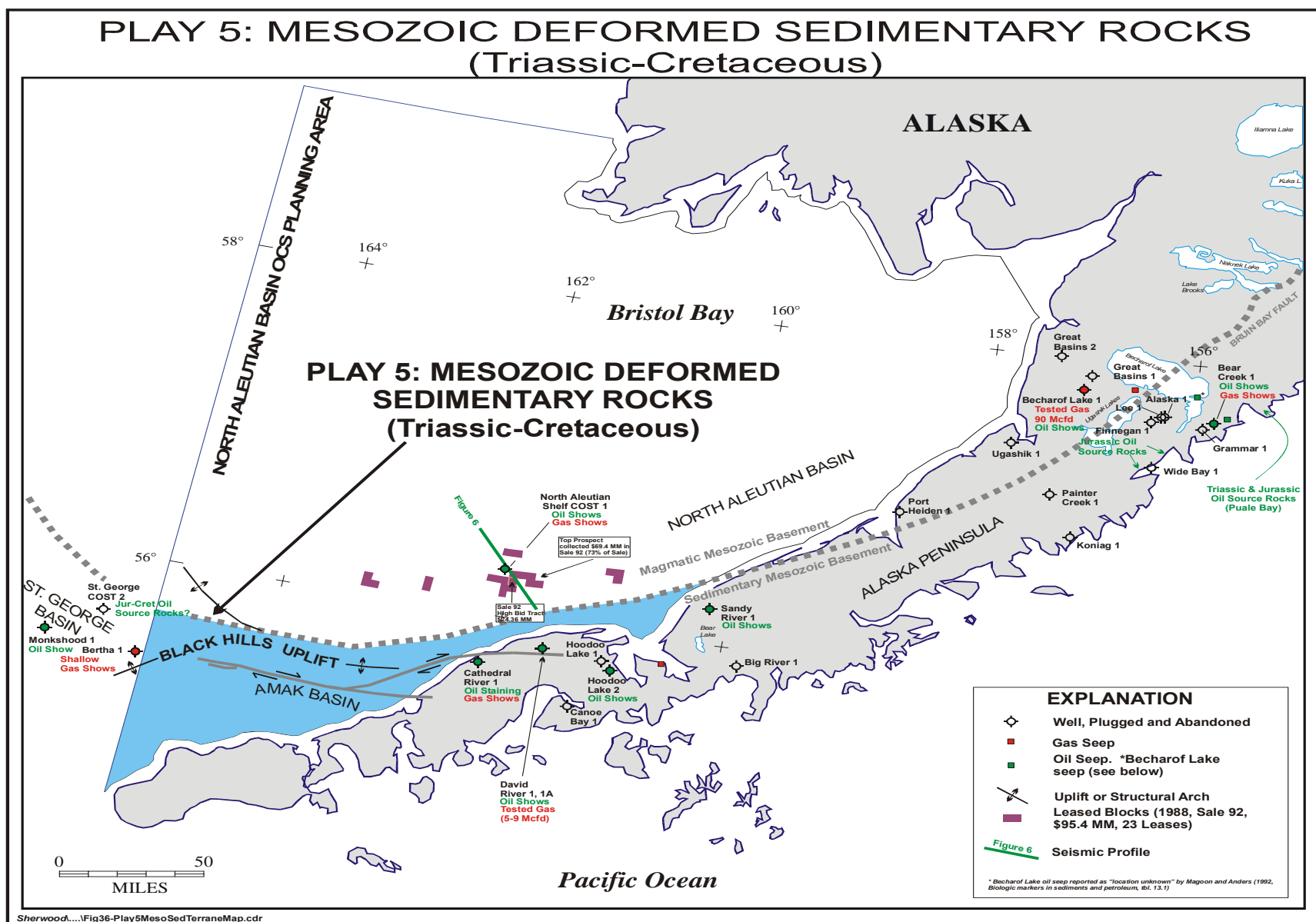


Figure 1. Map showing location of North Aleutian basin play 5, 2006 assessment.