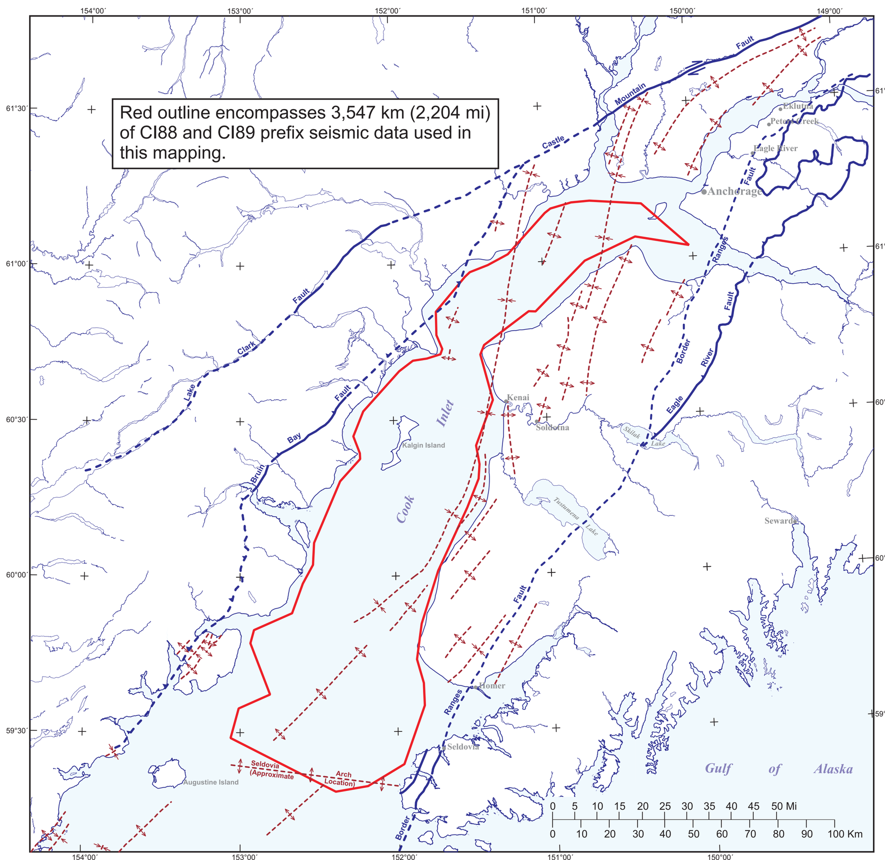
Location Map



Map Symbols

Fault - dashed where approximately located

- Strike-slip fault
- Thrust fault - sawteeth on upper plate
- Thrust fault - sawteeth on upper plate (seismic derived)
- Normal fault (seismic derived)

Fold axis - dashed where approximately located

- Anticline
- Syncline
- Anticline
- Syncline

Depth contours - dashed outside of seismic control; queried where inferred or doubtful

- Red line on location map above denotes area of seismic reflection data used in this study
- -5000 Index contour (depth in feet relative to sea level datum)
- Intermediate contour
- •36 Well with base Tertiary penetrations
- Oil accumulation
- Gas accumulation

*Oil and gas accumulations are displayed for reference only. They are typically located within the shallower Tertiary section, not at the mapped surface.

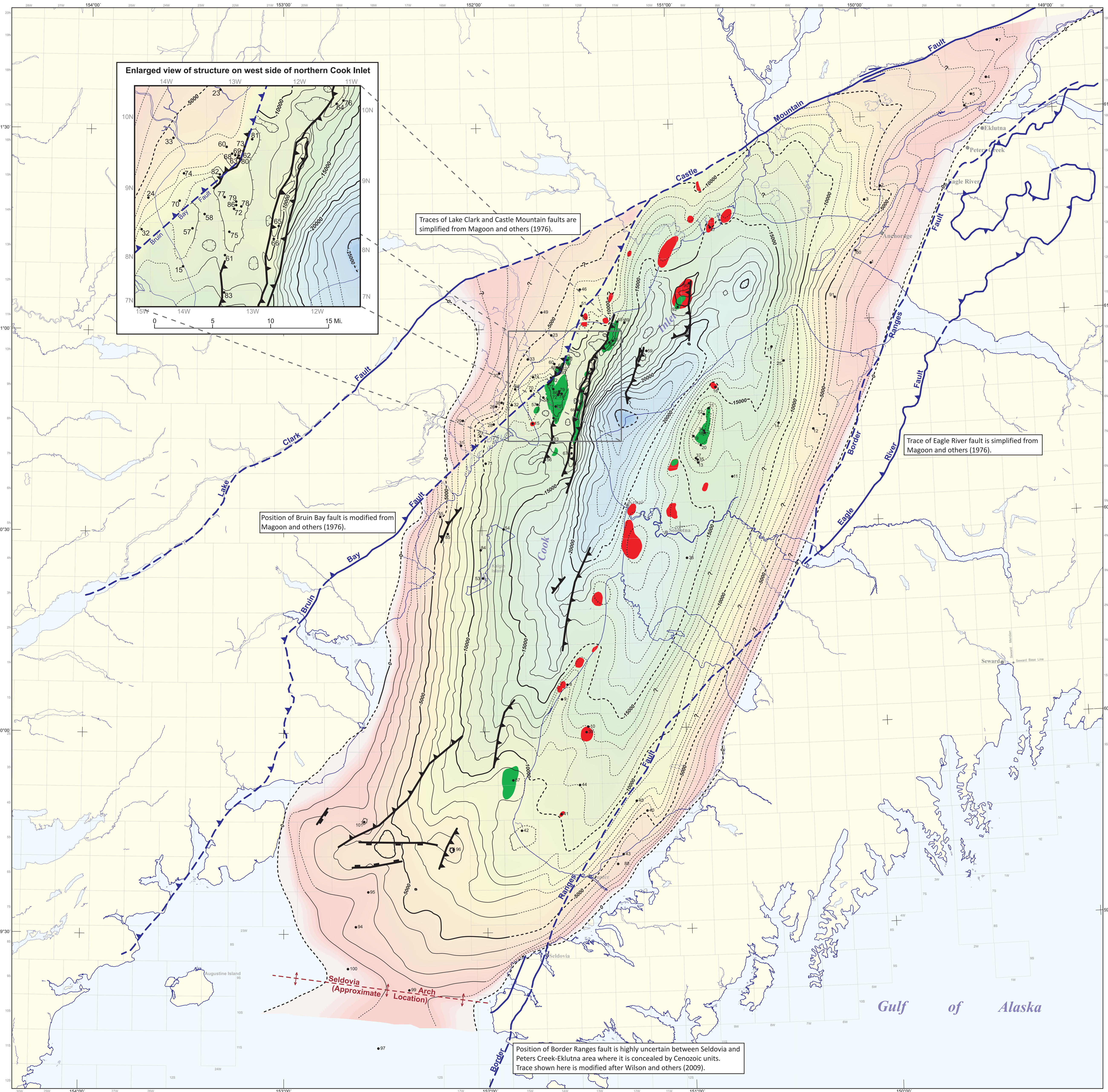
-25000 -19000 -13000 -6500 0

Vertical depth in feet
Datum: Sea Level

Table 1. Depth to top Mesozoic unconformity in oil and gas wells (ordered by API Number).
Well locations, borehole logs, and deviation surveys from the Alaska Oil and Gas Conservation Commission.
Measured depth pick interpreted by the Alaska Division of Oil and Gas.

Well Number	API No.	Well Name	Measured Depth (ft)	True Vertical Depth, Subsea (ft)
1	50009100010000	ROMIG PARK INC - 1	2635	-2494
2	50009100030000	KNIK ARM ST - 1	3620	-3521
3	50009100040000	LORRAINE ST - 1	7100	-6859
4	50009100090000	J M NEEDHAM - 1	2121	-1742
5	50009100110000	WALLACE KNUTSON - 1A	3453	-3309
6	50009100120000	WASILLA ST - 1	2970	-2937
7	50009200020000	FISHHOOK - 1	1950	-1230
8	50133100020000	NINILCHIK UNION - 1	12700	-12373
9	50133100030000	NINILCHIK UNIT MOBIL - 1	12183	-11946
10	50133100047000	DEEP CK - 1RDPB1	13780	-13143
11	50133100170000	NAPTOWNE UNIT - 24-08	14705	-14425
12	50133100210000	SWAN LK UNIT - 2	5850	-5725
13	50133100220000	SOLDOTNA CK UNIT - 22-32	13685	-13330
14	50133100250000	SWAN LK UNIT - 1	11587	-11232
15	50133100280000	W FORELAND - 1	11494	-11404
16	50133100290000	BIRCH HILL UNIT - 22-25	15220	-14992
17	50133100360000	PT POSSESSION UNIT - 1	14895	-14680
18	50133101090000	SOLDOTNA CK UNIT - 341-04	11090	-10910
19	50133101160000	HALASKO KING OIL - 1	11830	-11705
20	50133101310000	SOLDOTNA CK UNIT - 12-16	12200	-12034
21	50133101360000	SWANSON RIV UNIT - 34-10	12020	-11666
22	50133101450000	SWANSON RIV UNIT - 34-16	12137	-11859
23	50133200050000	MIDDLE RIV ST SHELL - 1	5250	-5124
24	50133200300000	KUSTATAN RIDGE - 1	6686	-6592
25	50133200610000	SWANSON LKS - 1	12043	-11801
26	50133201540000	KUSTATAN RIV - 1	3828	-3780
27	50133201700000	JOHNSON SLOUGH - 1	6090	-6045
28	50133201770000	BACHATNA CK ST 36448 - 1	6170	-6138
29	50133202340000	BACHATNA CK UNIT - 1	3030	-2990
30	50133202350000	BACHATNA CK UNIT - 3	2825	-2765
31	50133202360000	BACHATNA CK UNIT - 7	2597	-2555
32	50133202500000	W FORELAND ST A - 1	8606	-8549
33	50133202660000	W MCARTHUR RIV UNIT-INEXCO - 1	5746	-5707
34	50133202930000	SOLDOTNA CK UNIT - 33-33	11601	-11446
35	50133203620000	WOLF LK ARCO CIRI - 1	13075	-12801
36	50133203650000	FUNNY RIV ARCO CIRI - 1	16650	-16221
37	50133203750000	WOLF LK ARCO CIRI - 2	13350	-12738
38	50133204320000	KUSTATAN-CHEVRON - 1	5190	-4866
39	50231100010000	HAPPY VALLEY - 31-22	13209	-12580
40	50231100030000	ANCHOR RIV - 1	6720	-5224
41	50231100040000	N FORK UNIT - 41-35	11040	-10260
42	50231100050000	ANCHOR PT - 1	8974	-8719
43	50231100060000	FRITZ CK - 1	3580	-3425
44	50231200020000	N FORK UNIT - 11-04	12120	-11007
45	50231200030000	S CARIBOU HILL UNIT - 1	9964	-8047
46	50283100070000	STEDATNA CK - 1	7080	-6326
47	50283100080000	IVAN RIV UNIT - 44-01	15135	-15082
48	50283100300000	TYONEK ST 17587 - 2	12260	-12154
49	50283200010000	COTTONWOOD ST - 1	4140	-4061
50	50283200140000	CAMPBELL PT - 1	4315	-4252
51	50283200340000	W TYONEK - 1	6620	-6195
52	50283200360000	NICOLAI CK UNIT UNION - 5	8540	-8451
53	50733100090000	OLDMAN'S BAY ST - 1	11640	-11431
54	50733100150000	KALGIN IS ST - 1	14101	-14056
55	50733100160000	DRIFT RIV ST - 1	5010	-4951
56	50733100240000	REDOUBT SHOAL ST 22064 - 1	14239	-14208
57	50733100260000	W FORELAND UNIT - 1	10912	-10812
58	50733100350000	W FORELAND UNIT - 4	11070	-11141
59*	50733100370000	STATE SRS - 1	16130	-16199
60	50733100410000	MIDDLE RIV ST ARCO - 1	6954	-6873
61	50733100450000	KUSTATAN-UNION - 1	11737	-11373
62	50733100520000	TRADING BAY - 1A	6010	-5983
63	50733100560000	TRADING BAY ST - A-02	6605	-6291
64	50733100590000	GRANITE PT - 1	11508	-11447
65	50733100770000	MIDDLE GROUND SHOAL ST SRS - 1	9049	**-9005**
66	50733100820000	MIDDLE GROUND SHOAL - A43-11	9712	-9549
67	50733200240000	FORELAND ST UNIT - 1	12035	-12001
68	50733200310000	W TRADING BAY ST - 1	6251	-6211
69	50733200760000	TRADING BAY ST - A-12	7255	-6275
70	50733200960000	W FORELAND UNIT - 5	8585	-8494
71	50733201280000	KUSTATAN RIV UNIT - 43-30	10440	-10362
72	50733201300000	TRADING BAY UNIT - G-07	11205	-10422
73	50733201340000	N TRADING BAY UNIT - SPR-04	9985	-9187
74	50733201380000	MIDDLE RIV ST UNIT - 2	8080	-7792
75	50733201680000	TRADING BAY UNIT - D-17	11630	-10746
76	50733201730000	GRANITE PT ST 18761 - MUCI-1	13365	-12041
77	50733201780000	TRADING BAY UNIT - G-19	12033	-10985
78	50733201940000	TRADING BAY UNIT - G-31	12476	-10459
79	50733201980000	TRADING BAY UNIT - G-32	11535	-10323
80	50733202140000	TRADING BAY ST - A-11	7180	-6924
81	50733202330000	N TRADING BAY UNIT - S-08	11730	-10745
82	50733203250000	W TRADING BAY - 1	8660	-8300
83	50733203610000	S MCARTHUR RIV - 1A	12830	-12149
84	50733203720000	BEARD ST - 1-11	11246	-11126
85	50733204180000	STURGEON - 1	6894	-6830
86	50733204280000	TRADING BAY UNIT - M-29	11191	-10340
87*	50831100020000	STARICHKOF ST - 1	8750	-8682
88	50831100070000	COAL BAY ST - 1	3965	-3908
89	50883100020000	TYONEK ST 17588 - 1	13200	-13111
90	50883100180000	N COOK INLET ST - 1	14220	-14291
91*	50883200050000	TURNAGAIN ARM UNIT - 1	4213	-4143
92*	50883200850000	N FORELAND ST - 1	15569	-15451
93*	55219000050000	OCS 0168 COHO - 2	4052	-4001
94*	55220000010000	OCS COST LOWER COOK INLET - 1	2550	-2459
95*	55220000020000	OCS 0097 RAVEN - 1	2595	-2505
96*	55220000030000	OCS 0086 GUPPY - 1	5010	-4965
97*	55220000050000	OCS 0136 BEDE - 1	3505	-3427
98*	55220000060000	OCS 0152 BOWHEAD - 1	3935	-3856
99*	55220000070000	OCS 0124 S ARCH - 1A	1350	-1271
100*	55220000080000	OCS 0113 IBIS - 1	670	-591
101*	55220000090000	OCS 0243 FALCON - 1	1995	-1884

*Denotes wells with sonic and density logs.
Yellow denotes wells with publicly available check shots.
Green denotes wells with good synthetic ties to seismic.



Base from State of Alaska, Department of Natural Resources,
Alaska Statewide Core GIS database.
Universal Transverse Mercator Projection Zone 5 North
GCS North American 1983
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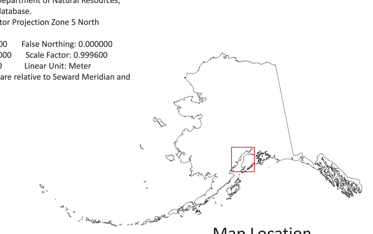
Central Meridian: -153.000000 Scale Factor: 0.999600
Latitude of Origin: 0.000000 Linear Unit: Meter
Township Range grid labels are relative to Seward Meridian and Base Line

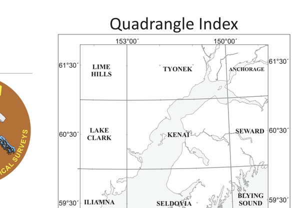

Map Location

Alaska Department of NATURAL RESOURCES Division of Oil and Gas

Scale 1: 500,000

10 0 10 20 30 40 50 Miles

10 0 10 20 30 40 50 Kilometers



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TOP MESOZOIC UNCONFORMITY DEPTH MAP OF THE COOK INLET BASIN, ALASKA

by

Diane P. Shellenbaum[1], Laura S. Gregersen[1] and Paige R. Delaney[2]

2010

Top Mesozoic Unconformity Depth Surface Construction

Introduction

This map shows the depth (in feet below sea level) to the top Mesozoic unconformity, an important stratigraphic horizon in the Cook Inlet basin, Alaska. Since 1957, more than 1.3 billion barrels of oil and more than 7.7 trillion cubic feet of gas (Alaska Division of Oil and Gas, 2010) have been produced from the Cook Inlet basin, nearly all of it from Tertiary strata that overlie the top Mesozoic unconformity. The source rock for the oil is located in the Mesozoic, and multiple wells have encountered oil shows while drilling through Mesozoic stratigraphy.

The map was constructed primarily from marine seismic reflection data and oil and gas wells that penetrated the top Mesozoic unconformity. Where the well control is too dense to differentiate at the 1:500,000 scale, an inset map is provided. The map was prepared as part of a multi-year, multi-faceted effort by the Alaska Department of Natural Resources to provide the public with the most accurate information possible on the geologic framework of this economically important area.

Well Interpretation

All public wells were obtained from the Alaska Oil and Gas Conservation Commission (AOGCC). The wells that penetrated the Mesozoic unconformity are listed in table 1, Depth to top Mesozoic unconformity in oil and gas wells. The depth to the top Mesozoic unconformity recorded in the table was interpreted using borehole geophysical log character, lithologic logs, and palynology data (Zippi, 2006). Where available, sonic and density logs were edited and combined to create synthetic seismograms (denoted by an asterisk in table 1) used in calibrating to the seismic data.

Seismic Interpretation

(See Location Map for area of two-dimensional seismic coverage)

The seismic dataset used for interpretation consists of 3,547 km (2,204 mi) of proprietary, speculative two-dimensional marine data (CI88 and CI89 prefix lines, owned and marketed by CGGVeritas). Together, these surveys include 97 lines with typical spacing of 2.5–8 km (1.5–5 mi), representing a high-quality regional dataset, used by the Alaska Department of Natural Resources with permission from CGGVeritas.

To tie the seismic data to the well data, calibrations were attempted for all synthetic seismograms of wells on or near seismic lines. Well ties to seismic were analyzed both visually and statistically. Data quality challenges included incomplete or missing logs, hole problems, coals (which cause washouts and significant inter-bed multiples and associated loss of transmitted energy), and out-of-plane energy. Only two wells, the North Foreland St. #1 and OCS 0168 (Coho) #2, highlighted in green on table 1, yielded synthetic seismogram to seismic ties of good quality to the top Mesozoic unconformity. The remainder of the synthetic seismograms were useful in predicting the seismic character of the West Foreland Formation.

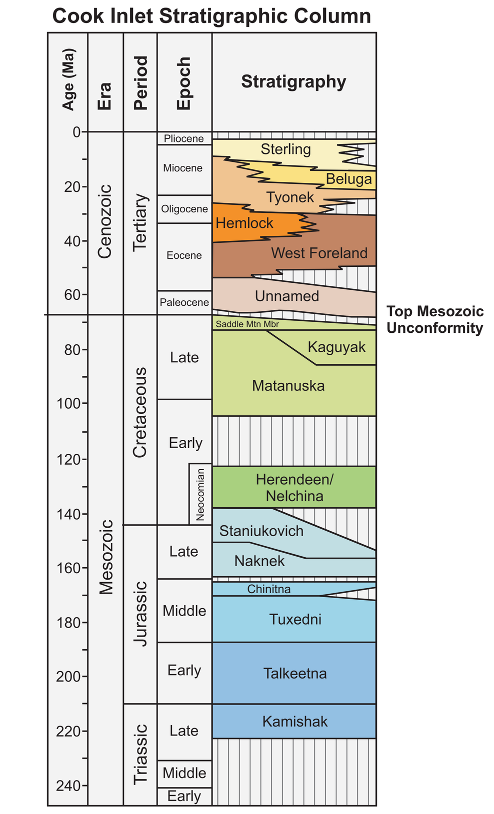
Check shot velocity surveys were publicly available from two wells, OCS 0243 (Falcon) #1 and OCS 0086 (Guppy) #1, and are highlighted in yellow on table 1. Depth-variant velocities were calculated from the synthetic seismogram ties and from the measured check shots to generate a depth and spatially variant velocity field. This field is highly under sampled from a full basin structural perspective, but was still helpful as a first pass depth-to-time conversion in projecting well formation tops onto the seismic.

The following data and observations were integrated to generate the top Mesozoic unconformity seismic interpretation:

- Time-to-depth relationships based on synthetic seismograms and checkshot velocity surveys
- Top Mesozoic unconformity well picks displayed in time
- Top West Foreland Formation seismic interpretation. This prominent seismic horizon is a short distance above, and generally conformable with, the top Mesozoic unconformity. Synthetic seismograms at this horizon generally showed a significant decrease in acoustic impedance, which should translate to a consistent strong reflector on the seismic. Interpretation of this horizon helped guide the underlying top Mesozoic unconformity pick.
- The top Mesozoic is sometimes an angular unconformity, and seismic reflectors below it can have steeper dips, and be truncated by the unconformity surface.

Seismic time-to-depth conversion: Final two-way time seismic picks on the top Mesozoic unconformity were gridded to form a surface. Time values were extracted at well penetrations by piercing the time surface with the well paths. The top Mesozoic unconformity depths at the well penetrations were divided by one-way time values to create 'pseudo-velocities', or average velocities from the horizon to the surface.

Cook Inlet Stratigraphic Column



Redrawn from Curry and others (1993) and Swenson (2003).

An implicit assumption in this depth conversion methodology is that the structural dip varies smoothly between control points. However, wells are mostly drilled on major structural highs in Cook Inlet, resulting in additional velocity control points being needed in areas of inadequate sampling, predominantly in the deeper parts of the basin. The additional control point values were estimated from cross plots of time versus pseudo-velocity, extrapolating an interpreted time-velocity slope to the deeper times observed on the seismic. The velocities from well penetrations and added control were then gridded to form a horizon velocity surface, which was multiplied with the seismic one-way time surface to create a depth surface. The depth surface contours were hand edited to remove computer-generated artifacts, which were especially apparent on the edges of seismic control and near faults and other areas of strong structural variability.

Interpretation Outside Seismic Control

The following data were used to interpret the top Mesozoic unconformity depth surface where seismic was not available:

- Well penetrations. See table 1.
- Bounding faults and fold axes. In places, the western edge of the basin is bounded by faults (Bruin Bay, Lake Clark, and Castle Mountain) as mapped by Magoon and others (1976), locally modified where seismic data are available (see Location Map). The Border Ranges and Eagle River faults (Wilson and others, 2009) are displayed along the eastern edge of the basin, but their traces do not everywhere coincide with the zero depth contour of the top Mesozoic unconformity surface. This is particularly apparent in the Kachemak Bay area, where well and outcrop data indicate a significant thickness of Cenozoic basin fill overlying the concealed trace of the Border Ranges fault. In addition, it was noted that the surface fold axes from Magoon and others (1976) matched reasonably well with the subsurface top Mesozoic unconformity fold axes as mapped from seismic data, so the surface fold axes (shown on Location Map) were used to influence contours outside of areas controlled by seismic.
- Contacts between Mesozoic and Tertiary geologic units. From surface geologic mapping (Magoon and others, 1976; Wilson and others, 2009).
- Structural contour maps from AOGCC annual reports. The vast majority of Cook Inlet oil and gas fields are found in structural traps within the Tertiary section. Where seismic data are available, we noted that the top Mesozoic unconformity structure generally mimics the structure of shallower horizons that host the fields. Therefore, for areas outside seismic control, where a shallower structure contour map was available, the general shapes of those elements were projected to the top Mesozoic unconformity surface. Structure contour maps for some of the fields were not available from AOGCC annual reports, but even in those cases, top Mesozoic unconformity contours were shaped to imply a structural high under the assumption that all fields discovered so far occur in structural traps. It is very likely that many of these structures have fault involvement, but where no seismic data was available, no faults were mapped.

Uncertainty and Error

Contours outside of the CI88 and CI89 two-dimensional seismic coverage are dashed to indicate uncertainty. Contours outside seismic coverage with little well control have even higher uncertainties, and are designated with question marks. The absolute depth error at any given point on the map is difficult to quantify and results from uncertainties in (a) the depth pick in wells, (b) interpolation between and extrapolation away from wells, (c) time picks on seismic, (d) variations in the seismic velocity field, and (e) gridding, contouring, and smoothing artifacts, particularly in areas of sparse seismic and well control.

There is also a certain amount of spatial uncertainty regarding the intersection of the top Mesozoic unconformity horizon with the Bruin Bay and Castle Mountain–Lake Clark fault systems that bound the basin to the west. The fault traces (Magoon and others, 1976) indicate surface expression, whereas the base Tertiary surface lies at varying depths. The unconformity depth surface has been contoured as if the faults are single vertical entities, but the reality is certain to be more structurally complex. The magnitude of this spatial uncertainty depends on the dips and complexity of the faults as well as the depth of the base Tertiary surface. The deeper the surface and the shallower the actual fault dips, the larger the potential error.

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