Iniskin Peninsula Conventional and Unconventional Exploration Targets, Jurassic Tuxedni Group, Lower Cook Inlet Onshore, Alaska*

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Abstract

Since the turn of the century, the Iniskin Peninsula has been the object of several vintages of exploration—from the half a dozen cable-tool oil gushers drilled adjacent to surface oil seeps in the early 1900's, to deeper 8,775 to 11,231' depth wells drilled in the "high camp" area during the 1930's and 1950's, to the first 2D seismic survey conducted on the peninsula during 2013. Trap at Iniskin prospect consists of a southwestplunging, 55,000-acre, breached anticline, defined by surface geology, topography, oil seeps, oil shows in seismic shotholes, vintage magnetics, and 2D seismic. Early explorations concentrated on mapping out the surface geologic structure and the locations of oil and gas seeps. The first drilling campaign during the early 1900's concentrated on drilling the oil seeps in the Oil Bay area, and wells flowed oil and gas from 120', 190', 500', and 770' depths. During the early 1930's, and again in the 1950's, exploratory drilling concentrated to the northeast, up-plunge, in "high camp" area. These later wells all flowed oil and gas at noncommercial rates. Prospective oil and gas reservoirs consist of two radioactive organic mudrocks in the Middle Red Glacier Formation measuring 1292' and 300' thick, located within the oil generative window. In addition to these two unconventional targets, the uppermost Talkeetna volcanic breccia, plus sandstone beds within the Lower Red Glacier Formation, both display secondary dissolution porosity development and are highly prospective conventional targets. The 2D seismic acquired by Hilcorp during 2013 indicates that all of the wells drilled to date have missed the crest of the deeper structure, and that the anticlinal axis at the surface is offset to the west relative to the deeper anticlinal crest. In addition to conventional reservoir targets, numerous low-porosity, low-permeability oil saturated sandstones exist, which might be commercialized given modern lateral and/or hydraulic fracturing technologies. The remaining risk parameters at Iniskin—source rocks and timing and migration—are mitigated inasmuch as: 1) oil seeps located at N 59° 40.603 minutes latitude, W 153° 19.447 minutes longitude, elevation 65.7', consist of 16 API green-brown, sweet oil, typed to Jurassic Tuxedni source rocks, and 2) live oil was observed in 8 seismic shotholes drilled along the crest of the surface anticline. Additional explorations are planned in the vicinity in the near future.

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D. Buthman, PSAAPG Convention

23 May 2017

INISKIN PROSPECT HISTORY



Historical Overview

- Pre-history: Native man and wildlife utilize oil seeps
- 1850's: Russian explorers discover oil seeps
- 1895: cable tool rig and boat sink, delays first drilling.
- 1900: First Drilling on Iniskin Peninsula near Oil Bay on oil seeps
- 1936-39: Havenstrite 1IBA well drilled: produced gas and 15 BO per hour of light green 46.8 API gravity crude, noncommercial.
- 1954-59: Beal well drilled, gas tested at 2454-2585, oil shows below 6000'; tested noncommercial volumes of oil and gas; tried hydrofrac three zones, with increase in high gravity black oil from 6871-7350'. "Needed proppant."
- 1958-61: Zappa well, noncommercial oil and gas shows from 1600-11231'.
- 1957: First commercial oil discovery at Swanson River
- 1959: Statehood
- 2001-04: Minerals ownership issues, could not lease
- May 10, 2011 report: Reservoir Potential of Tertiary and Mesozoic Sandstones, Cook Inlet Alaska, AAPG Pacific Section Meeting. Leplane, Wartes. et al.
- 2013: Hilcorp acquires 2D seismic data, CIRI lease option

Petroleum Systems



1. Conventional Petroleum System

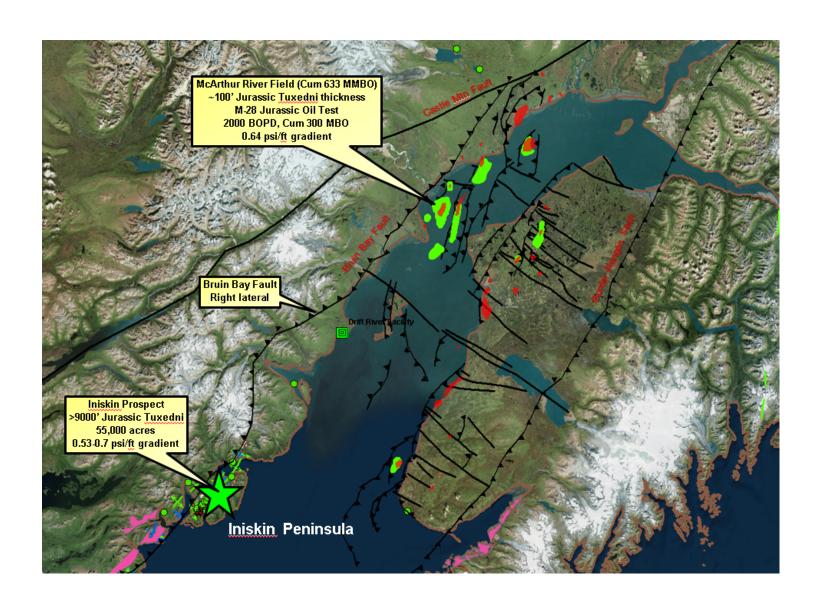
- Trap: 55,000+ acre closure on Fitz Creek anticline based on surface geology
- · Reservoirs:
 - low permeability Jurassic Tuxedni volcaniclastic greywackes and lithic sandstones intercalated with rich source rocks; 5-15% porosity, 0.001-50 md permeability.
 - High permeability unconformity breccia reservoirs.
 - Fractured reservoirs—large thickness and aerial extent, small recoveries per acre-foot
- <u>Source Rocks</u>: Jurassic Tuxedni mudrocks with TOC's >1% and Ro's 0.6-1.1; also speculative Puale Bay Triassic petroliferous argillaceous limestones and shales with 1-5% TOC and Ro>0.6.
- Seals: internal common
- Timing & Migration: current generation of hydrocarbons

Unconventional Resource Play:

- Extent: extremely large
- Reservoir: Tuxedni Group organic mudrocks
- Source Rocks:
 - TOC >0.5 from surface to 11,000', with richer sequence with TOC>1.0 from 6000-9500';
 - published reports of "3300' of 'oil saturated sediments" in the wells; abnormally high pressure environment, ranging from 0.68-0.77 psi per ft. Also has high geothermal gradient, approximately 18 deg F per 1000 ft.
 - Maturity: Ro 0.5-1.1, ranging from immature to highly mature (wet gas) from surface to 10000'
 - 16 API crude in shallow wells and oil seeps and 802 BTU gas in gas seeps in NW 11-T6S-R24W; through 46.8 API paraffinic crudes at 5601-7156, in the IBA well, geothermal steam test at 8499 at the Zappa well.

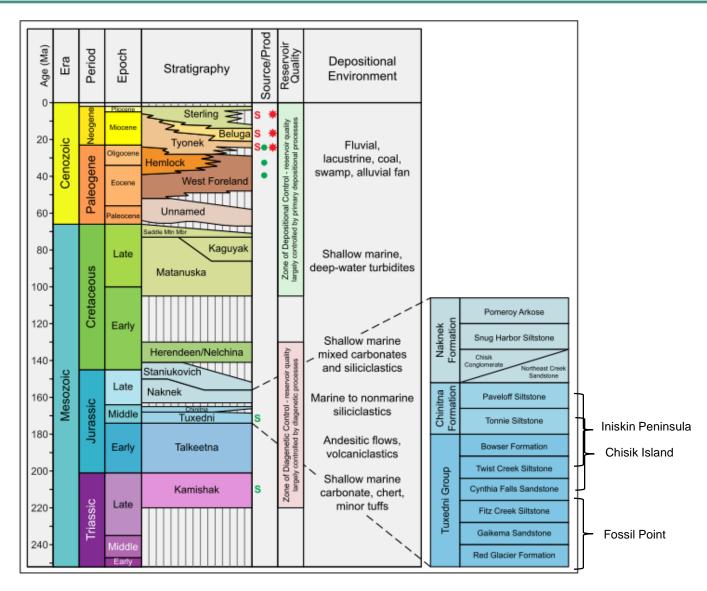
Basin Architecture - Faults





Stratigraphic Column

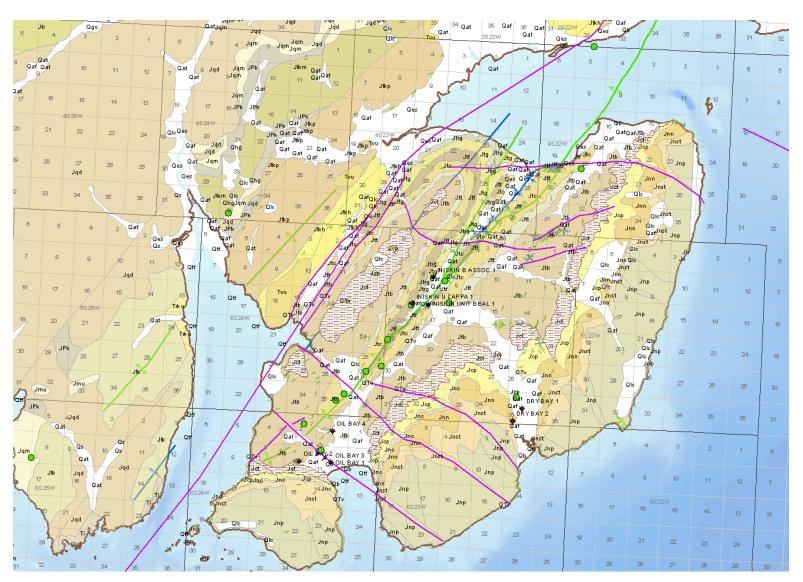




http://pubs.dggsalaskagov.us/webpubs/dggs/pir/text/pir2013_005.pdf

Surficial Geology





Modified from Wilson, Hults, Mull, Karl, 2015 Geologic Map of Alaska, USGS SIM 3340

View North Down Anticlinal Axis





Oil Seeps



October 2012: Field Reconnaissance.

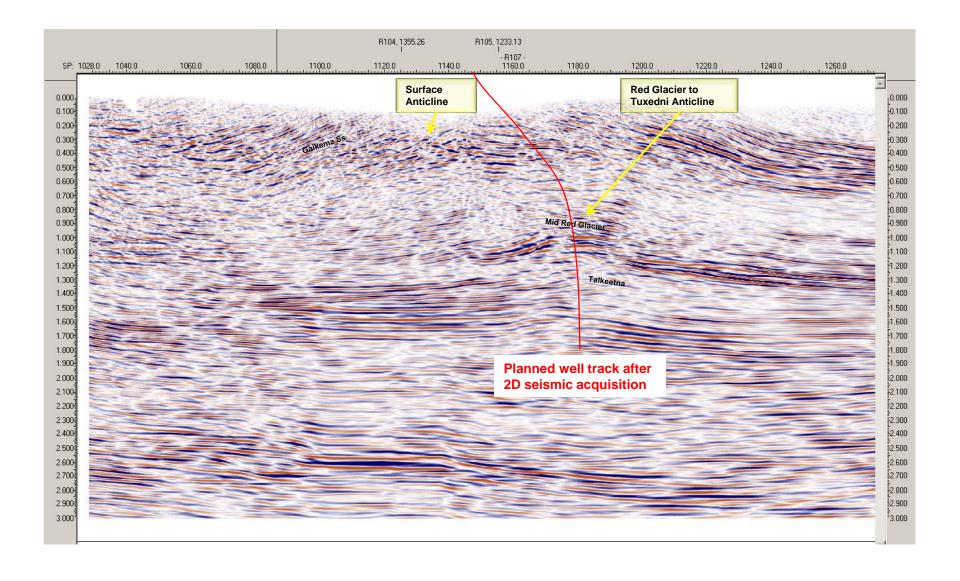
- Found two separate oil seeps emanating from the base of the hill into water springs and coming from jointed brown fine grained sandstone. Also, traced a thin 6 inch to 1 foot thick unconsolidated oil sand along the base of the hill about 200 meters northeast into the gully and up, so that it seems that the oil sand, though thin, is extensive in the outcrops. The oil seeps are located at N 59 degrees 40.603 minutes latitude, W 153 degrees 19.447 minutes longitude, elevation 65.7'.
- Spent several hours collecting oil in small glass sample vials. Filled two vials with green-brown oil, sweet oil:
 - 16.1 API Gravity @ 60 deg F.
 - 0.19 Wt% Sulfur
 - Whole Oil GC types to Jurassic Tuxedni
 - 3.5% asphaltenes





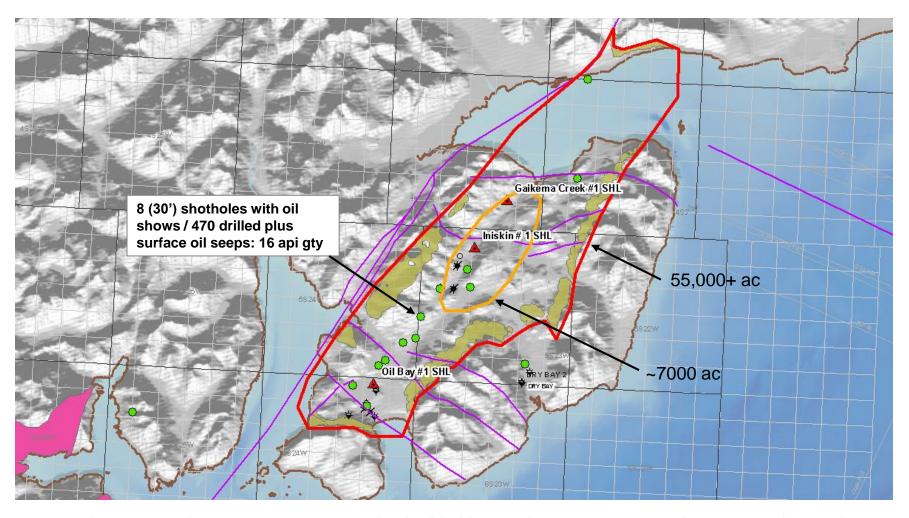
Dipline: Deep Structure Offset from Surface Anticline





Trap: Large Closed Anticline





Tonnie Siltstone Member outcrop: massive to thin bedded brownish gray arenaceous siltstone; weathers red brown; small yellowish-brown limestone concretions in parallel bands; minor sandstone at base.

Unconventional Reservoirs : Source Rocks & Joint Sets



Pennsylvania, joint sets = hypothesis Devonian shale gas expulsion features (Engelder et al., GSA Field Guide 20, 2011.



Chinitna Formation, Paveloff Siltstone Mbr, Oil Bay on Iniskin Peninsula (Gillis, et al, DGGS PIR 2013-1 Overview of 2012 field studies ...)





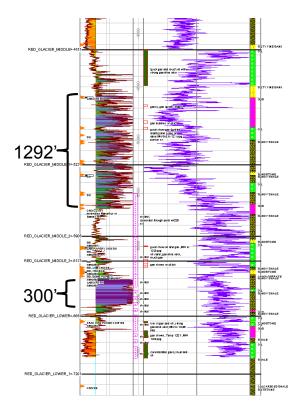
Red Glacier Formation Tuxedni Bay, Fossil Point transect. Closely spaced joint sets in known oil source rocks (author).

Organic Mudrock Plays: Red Glacier Fm





Tuxedni Group Red Glacier Formation source rock outcrops west of Fossil Point, Tuxedni Bay.



Organic-rich Mudrocks hot GR response

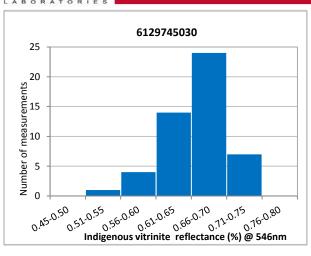
Vitrinite Reflectance



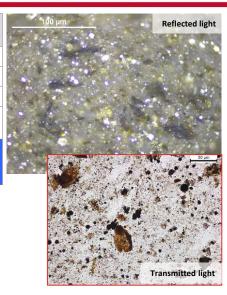


Project: HH-95865 Well: IBA 1

Vitrinite Reflectance and MOA



6129745030	Depth = 5660-5670
Minimum R _o (%)	0.55
Maximum R _o (%)	0.74
Number of points	50
Standard deviation	0.042
Mean R _o value of indigenous vitrinite (%)	0.66



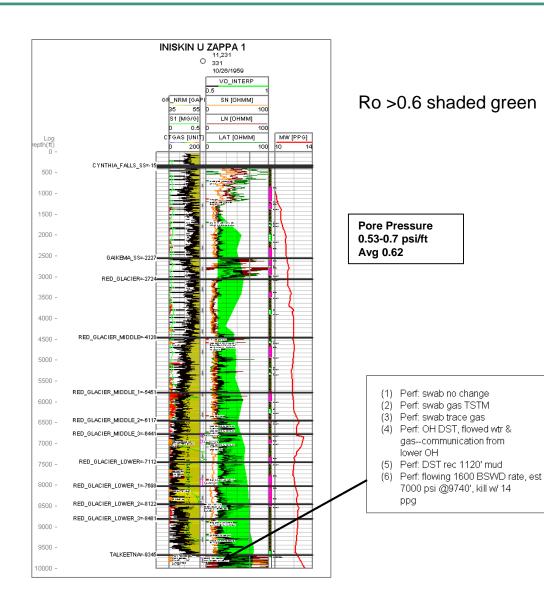
Ordered Royandom values of vitrinite

0.55	0.58	0.58	0.60	0.60	0.61	0.61	0.61	0.62	0.63
0.63	0.63	0.63	0.64	0.64	0.64	0.64	0.65	0.65	0.66
0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.67	0.67
0.67	0.67	0.67	0.68	0.68	0.68	0.69	0.69	0.69	0.69
0.69	0.69	0.70	0.71	0.71	0.71	0.72	0.74	0.74	0.74

 $\begin{array}{l} \underline{\textbf{Comments}} \colon \text{Both vitrinite and amorphous organic matter (AOM) are prominent in this sample. AOM occurs as brown wisps yellowish brown fluorescing to non-fluorescent. There is sporadic dull yellow fluorescing liptodetrinite. Vitrinite is distinct and occurs as irregular particles of various sizes. Inertinite is very rare and represented by small inertodetrinite particles. Pyrite is abundant. Based on 50 measurements, the average <math>R_o$ of vitrinite is 0.66%. In transmitted light, structureless organic matter is golden brown/yellowish brown, indicating TAI 2.5. Pollen and spores are brown amber to brown, the lightest assessing vitrinite reflectance at ~0.65%. Vitrinite reflectance data and TAI suggest that the organic matter is early mature and within the oil generation window.

Pressure Profile, Type Log





Conventional Tite Reservoirs



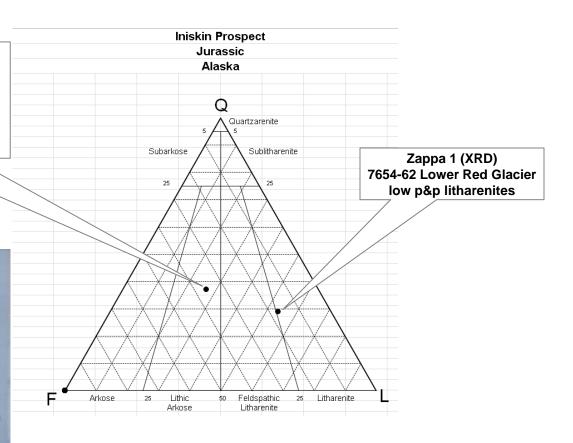
WELL NAME:	Beal #1	IBA	IBA	IBA	
DEPTH:	2515'	6120-24'	6339-46'	8012-16'	
Grain Size Avg. (mm):	0.07	0.08	0.31	0.43	
Grain Size Range (mm):	<0.01-0.23	<0.01-0.16	<0.01-0.71	<0.01-0.63	
Sorting:	Moderately Well	Moderately Well	Moderately Well	Moderate	
Fabric:	Burrowed	Laminated; Fractured	Slightly Burrowed	Fractured; Burrowed	
Rock Name (Folk):	Lithic Arkose	Feld. Litharenite	Litharenite	Lithic Arkose	

Sample No.	Sample ID	Depth	Porosity	Permeability				
		ft.	%	Air md				
1	Beal No. 1	2515	9.3	* 3.09				
2	IBA	1514-19	+ 11.2	**				
3	IBA	4695-7406	9.0	* 2.09				
4	IBA	5427-40	5.3	0.01				
5	IBA	6107-10	+ 11.6	0.28				
6	1BA	6120-24	10.7	**				
7	(IBA	6339-46	**	**				
8	IBA	8012-16	+ 15.3	**				
+	Data may be	somewhat	questionabl	e due to small	sample.			
*	Permeability measured on epoxy mounted rock chips.							
	Bypass may have occurred resulting in higher permeabliti							
**	Insufficient Sample for Analysis							

Conventional Reservoirs



Zappa 1 (XRD)
9729-43 unconformity breccia
laumontite breccia
Lithic arkose Talkeetna Volcanics
1600 BSWD test
Feldspar diagenesis replaced by
laumontite

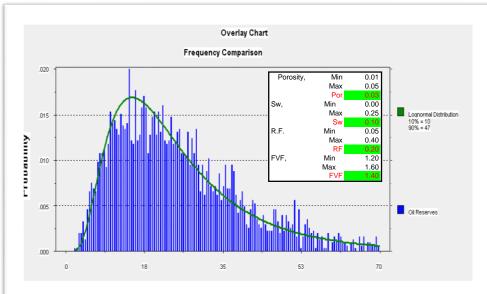


Fractured Reservoirs





Tuxedni Group, Cynthia Falls Fm, fracture sets, Fossil Point, Alaska, 6/8/2015



Fractured basement recovery factors, Unocal internal memo, 2001: BOAF

RESERVOIR ANALOGUES



Conventional Reservoirs –

- Lower Red Glacier sandstones
- Talkeetna Laumontite tuff breccia—produces in Jurassic folds in Georgia (ie., Samgori Field cum 165 MMBO)

Low p&p clastic reservoirs – collect swc's, etc

- Bone Spring, Delaware Basin, por 7-11%, perm 0.3-0.6 md, Rt>=10 ohm-m, Sw cutoff<=60%; vertical wells 100 BOD, horiz wells 500-1000 BOD avg first 30 days pdn.
- Upper Jurassic East Texas: Cotton Valley Ss, Taylor Ss, Bossier / Haynesville Shales, Buckner, Smackover, Norphlet

Organic Rich Mudrocks ("Shale Reservoirs"):

- Age-Based (Bajocian, ~Kimmeridgian, Oxfordian):
- Geochemical similarity: Wolfcamp & Avalon organic rich mudrock (OMR)
- Resembles in core: Barnett, Marcellus, Eagleford OMR

Fractured Reservoirs – (low recoveries per acre-ft, huge rock volumes)

- Cretaceous LaLuna Formation
- Bach Ho fractured granite reservoirs
- Triassic fractured sandstone oils in Bohai Bay Basin, China.
- Jurassic Nugget Sandstone at Tablerock Field, Wyoming, 2-3%por @15,000' gas
- Fractured Cambrian orthoguartzite basement oils, North Slope, Stinson #1 well (Blodgett, 2018)
- Monterrey, California

Acknowledgements



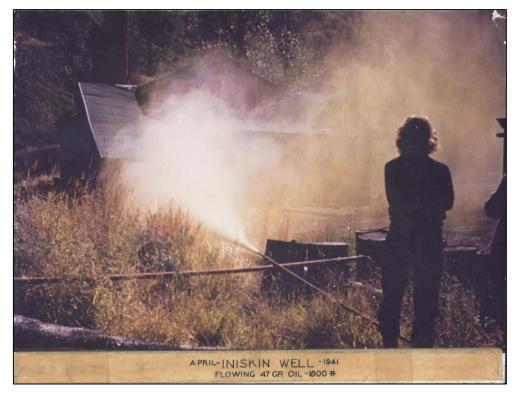
Hilcorp Alaska LLC

S. Deetz

J. Serbeck

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CIRI Robert Blodgett



Courtesy Robert B. Blodgett, 2012

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