

Nanushuk Formation Brookian Topset Play, Alaska North Slope

North American Prospect Expo 2017

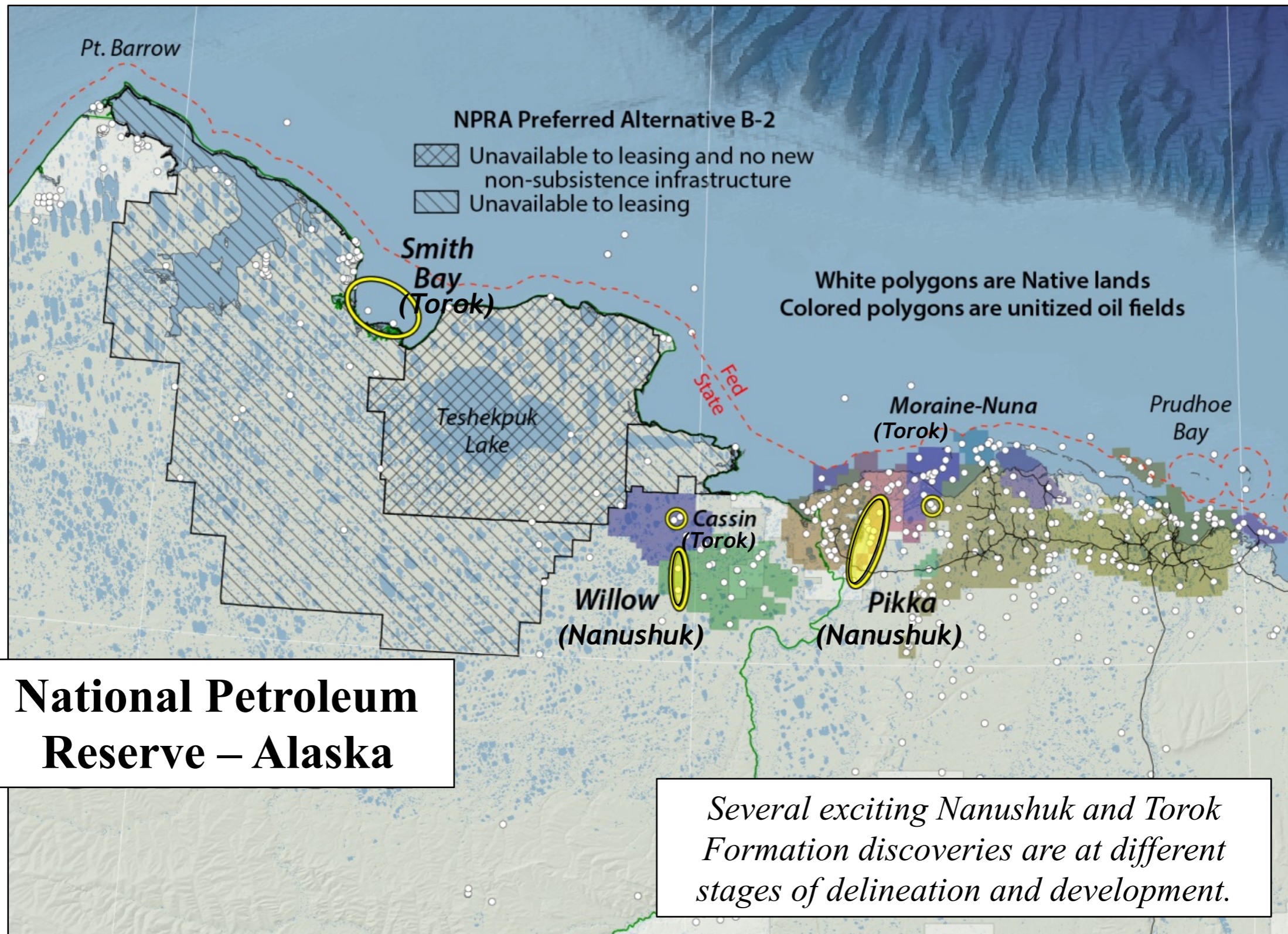


**Alaska Department of Natural Resources,
Division of Oil and Gas**

NAPE, February 2017



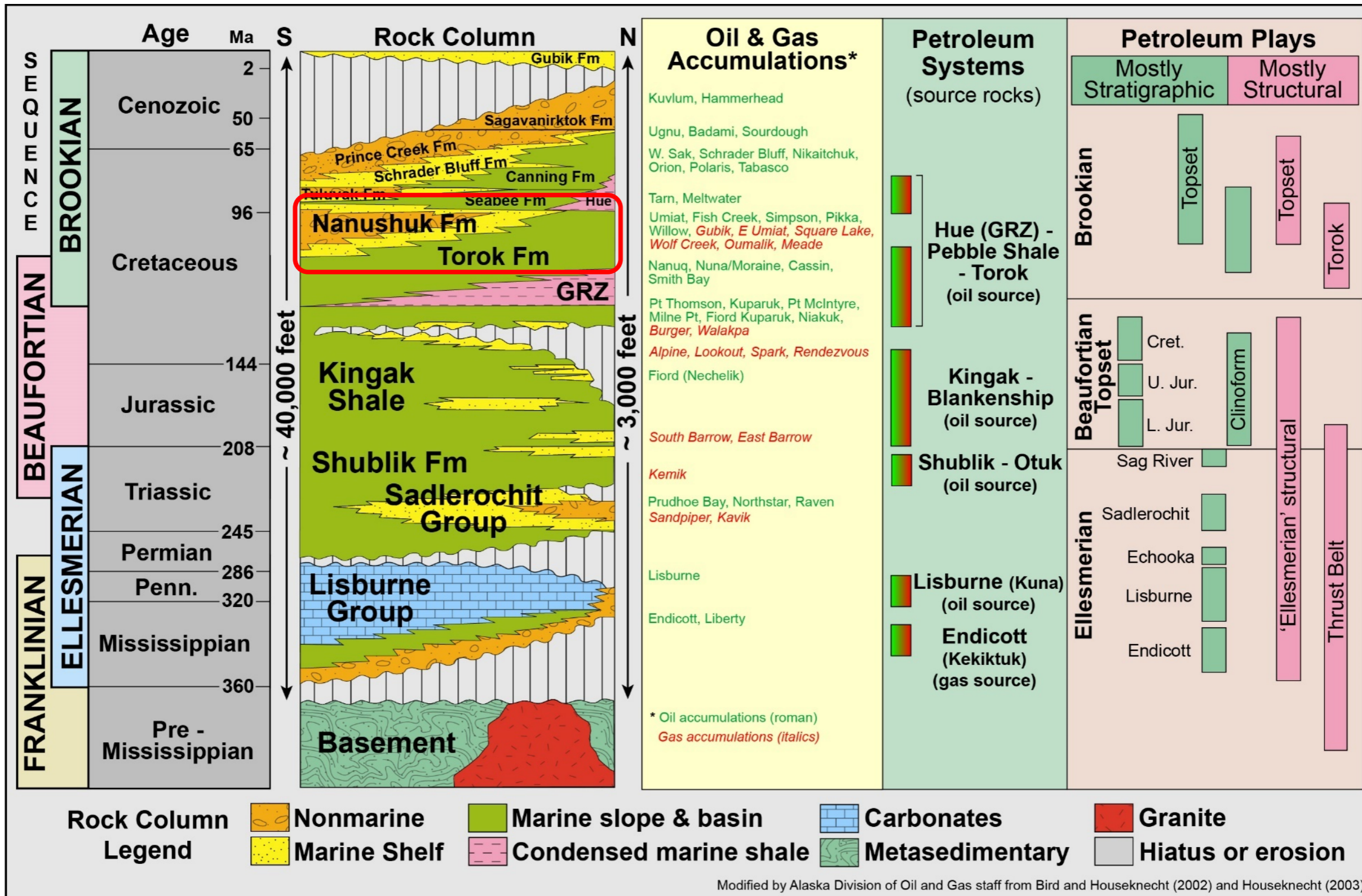
NORTH SLOPE BROOKIAN DISCOVERIES



MAJOR RECENT NANUSHUK DISCOVERIES

	Pikka	Willow
Operator	Armstrong	ConocoPhillips
Location	Onshore Colville Delta	Onshore Northeast NPRA
Depth to Reservoir	~ 4,200 ft TVD	~ 3,600 ft TVD
Trap type	Stratigraphic (faults?)	Stratigraphic
Net Pay	< 225 ft	42-72 ft
Oil Gravity	30 deg API	44 deg API
Test Rate	~ 2,100 bopd vertical; 4,600 bopd horizontal	< 3,200 bopd vertical
P50 Contingent Recoverable Resource	1,438 MMBOR includes deeper horizons	300 MMBOR
Expected Production	up to 120,000 bopd	40,000-100,000 bopd

NORTH SLOPE PETROLEUM SYSTEMS

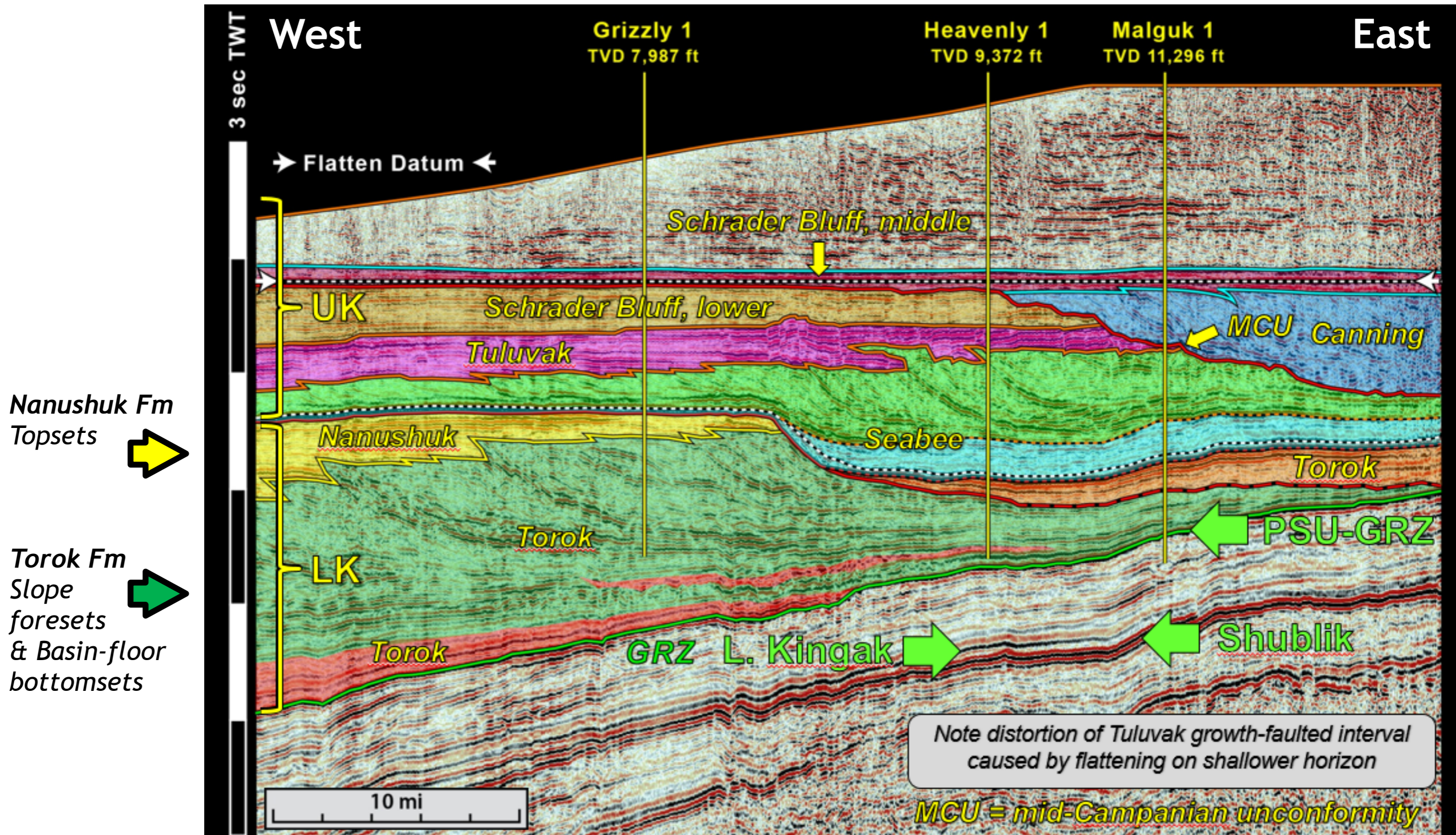


BROOKIAN SEQUENCE AND PLAYS

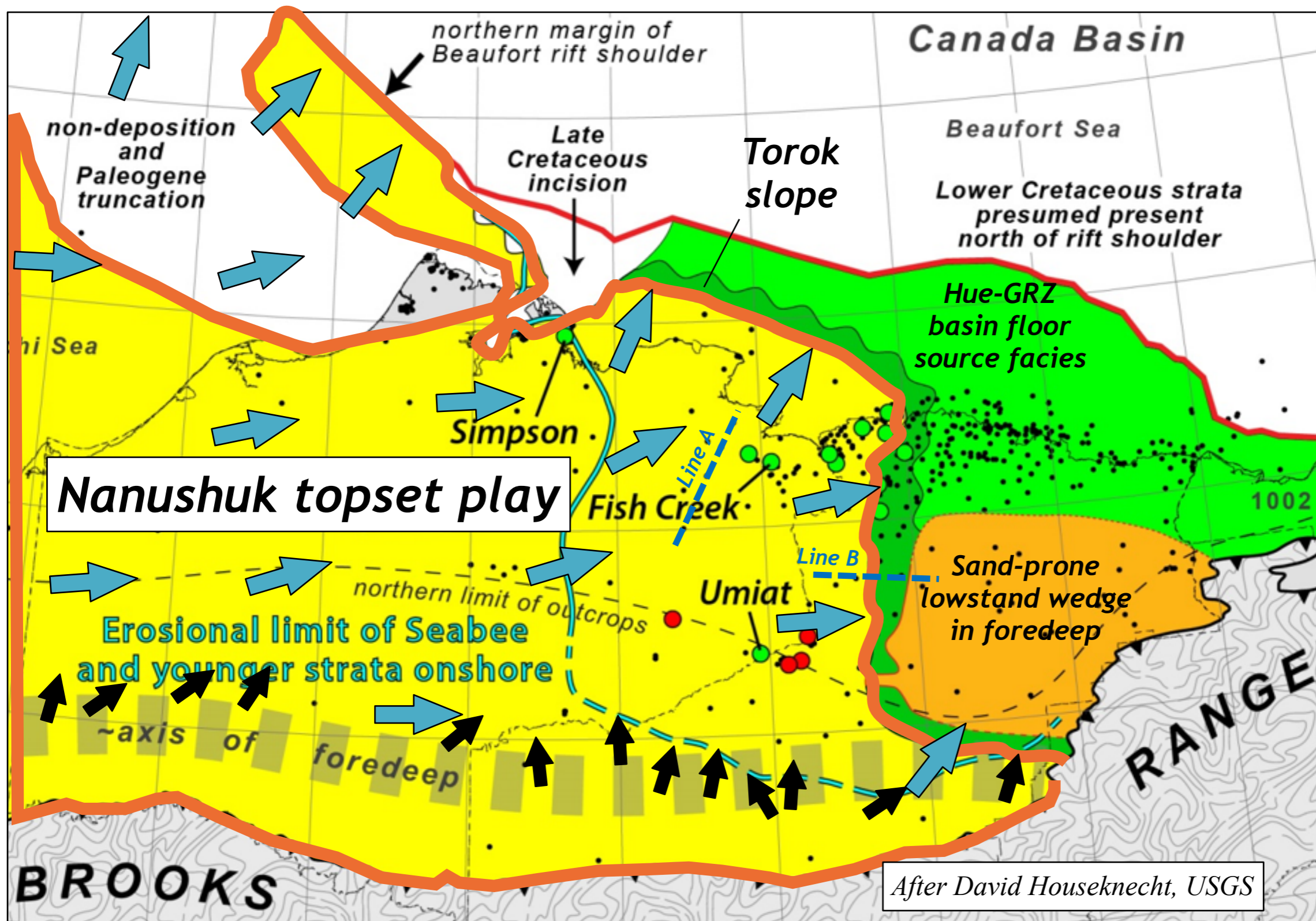
- The Brookian sequence represents a wide range of clastic rocks shed from the ancestral Brooks Range into the Colville foreland basin during Cretaceous and Tertiary time.
- Multiple formations make up the clinoformal succession, which filled the basin from west to east.
- Readily apparent in seismic, Brookian clinoforms consist of
 - *Topsets*: sand-prone coastal plain and shallow marine shelf
 - *Foresets*: muddy slope and sandy turbidite channels and slope apron fans
 - *Bottomsets*: sandy basin-floor turbidites, organic-rich condensed shales
- In the central to western North Slope, the topsets are the Nanushuk Formation, whereas the time-equivalent foresets and bottomsets represent the Torok Formation.
- Nanushuk tends to have superior reservoir quality due to matrix winnowing and less compaction (shallower burial)

CRETACEOUS BROOKIAN SEQUENCE

- LINE A -



MID-CRETACEOUS DEPOSITIONAL SYSTEMS



Clinoform Paleocurrents

Foreset dip (seismic)

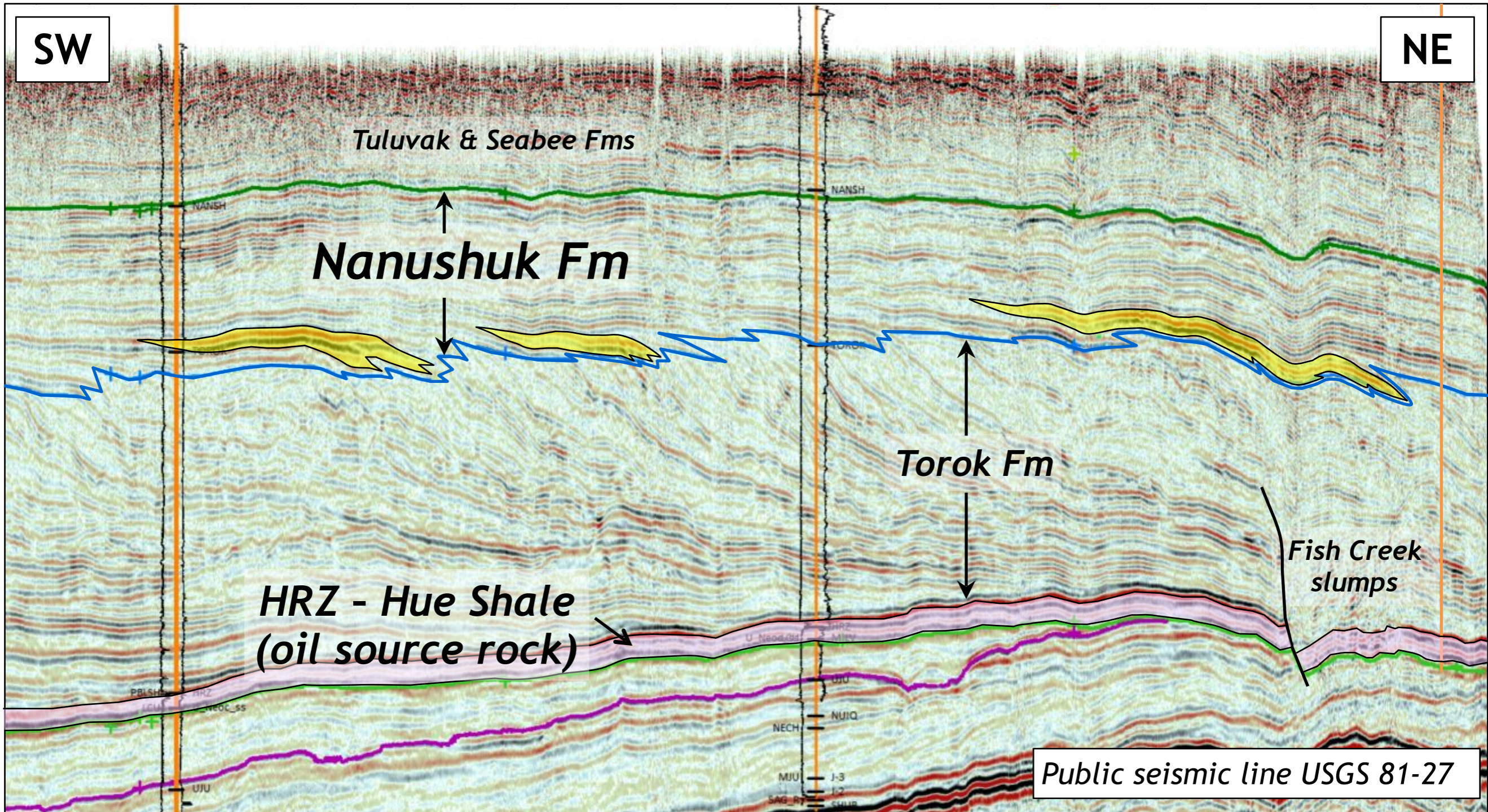
Topset crossbeds (outcrop)

BASAL NANUSHUK SEISMIC ANOMALIES - LINE B, NORTHEAST NPRA -

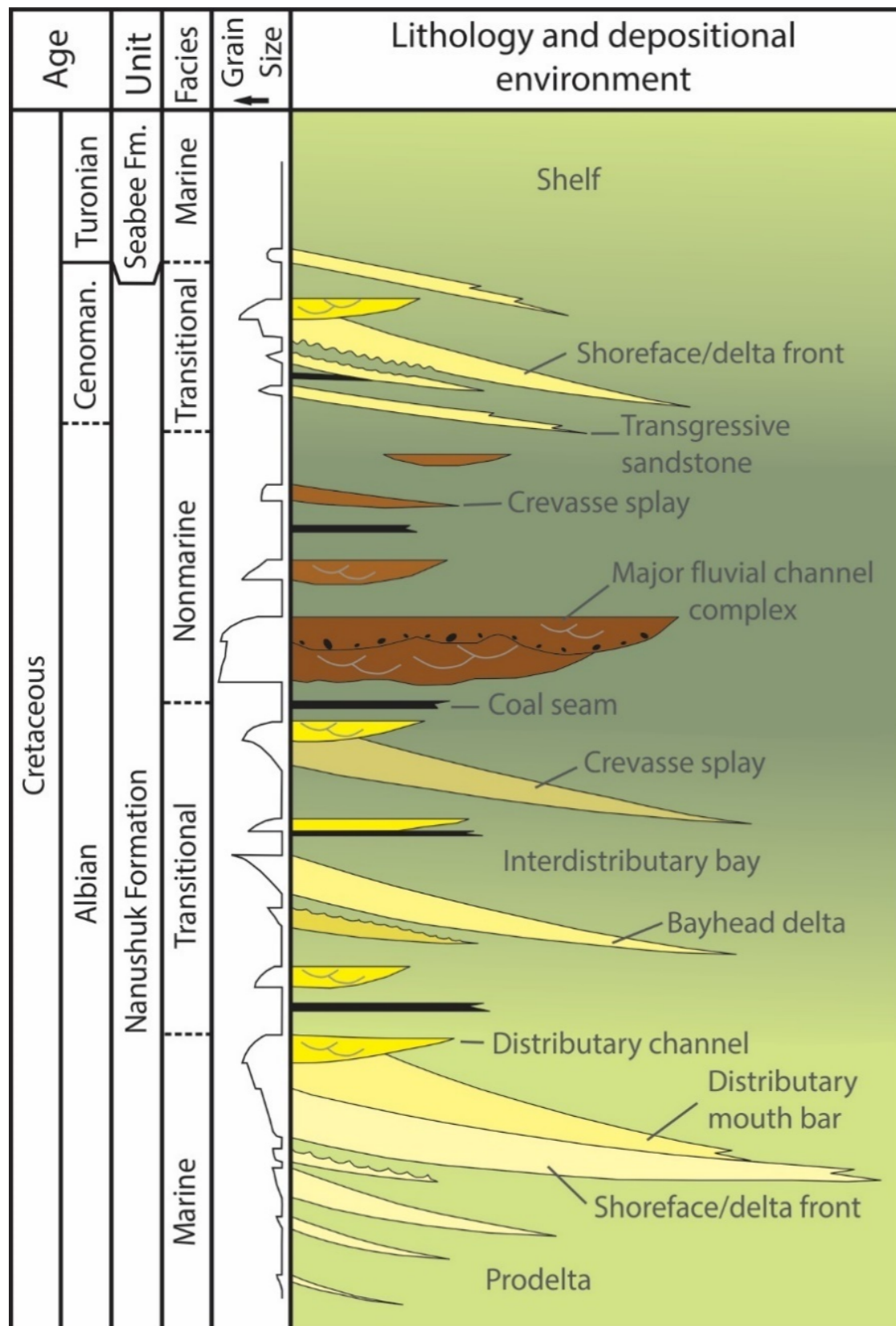
Inigok 1

North Inigok 1

North Kalikpik 1



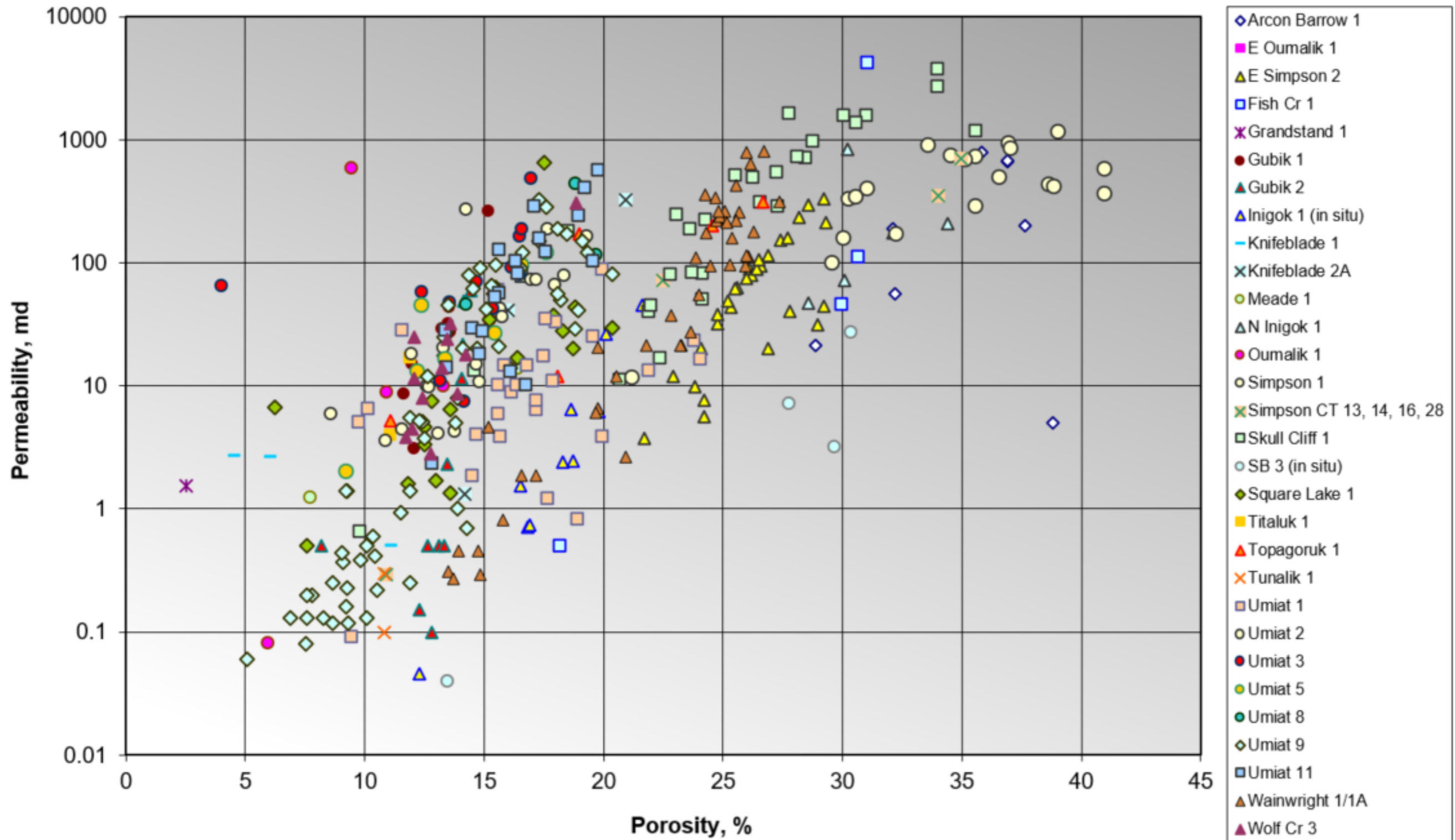
NANUSHUK GENETIC STRATIGRAPHY



Nanushuk Formation

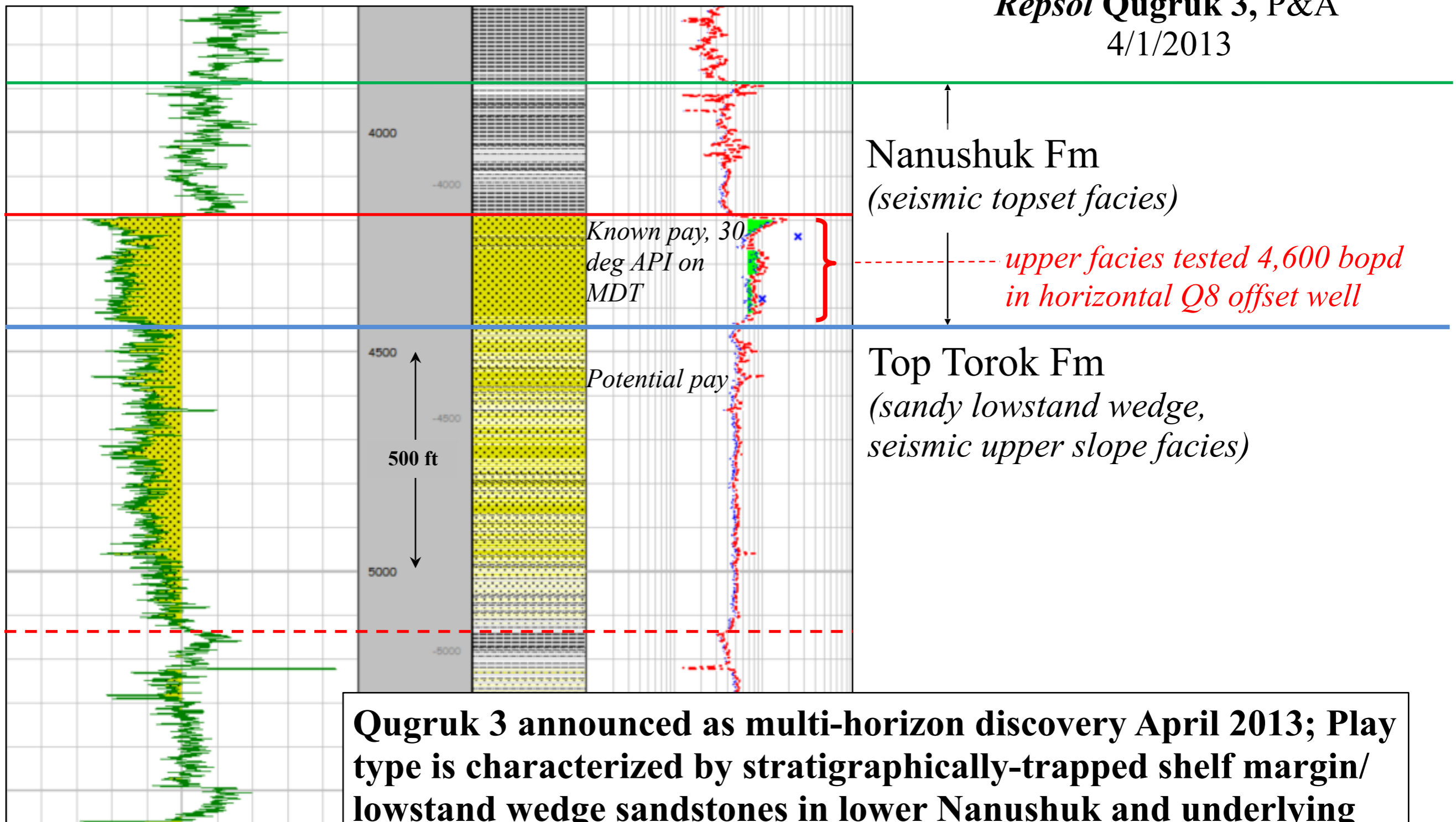
- Lower Cretaceous (Albian – Cenomanian)
- Shallow marine to nonmarine topsets with abundant reservoir-prone sandstone
- Genetic equivalent of Torok Formation slope foresets and basinal facies
- Nanushuk + Torok represent a major clinoformal succession that filled the western Colville foreland basin by prograding west to east, along basin axis
- Fully marine at base, transitions upward to mainly nonmarine, capped by marginal marine transgressive interval

NANUSHUK FM RESERVOIR QUALITY



PIKKA DISCOVERY - NANUSHUK FM

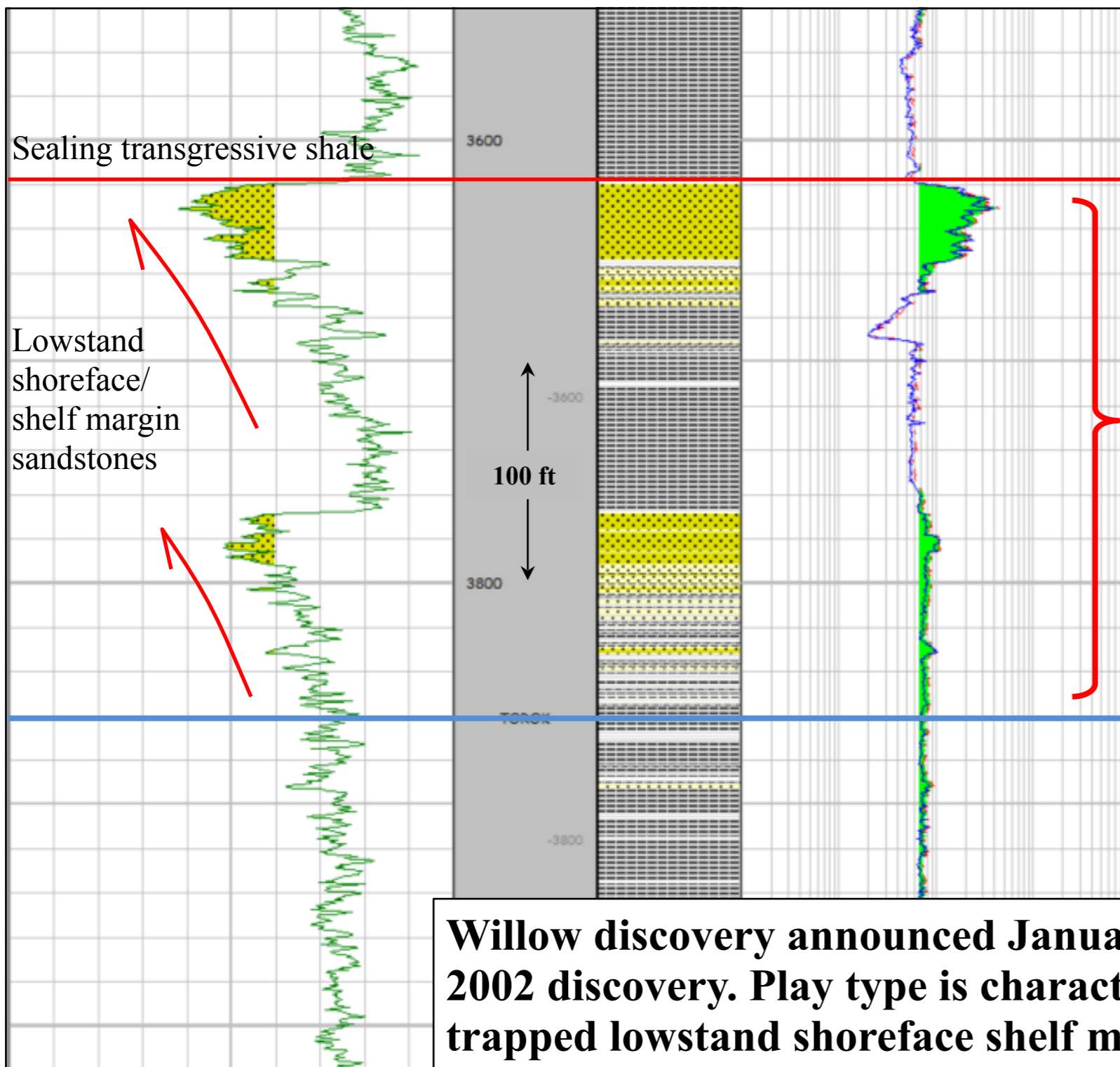
Repsol Qugruk 3, P&A
4/1/2013



Qugruk 3 announced as multi-horizon discovery April 2013; Play type is characterized by stratigraphically-trapped shelf margin/lowstand wedge sandstones in lower Nanushuk and underlying sandy slope Torok Formation.

WILLOW DISCOVERY - NANUSHUK FM

*ConocoPhillips Hunter A, P&A
3/26/2002*



Lower part of Nanushuk Fm
(basal topset facies)

Willow interval: secondary objective with light oil/gas shows; Tinmiaq 2 and 6 wells confirmed discovery with up to 3,200 bopd test.

Top Torok Fm
(uppermost slope facies)

Willow discovery announced January, 2017 was a follow-up of this 2002 discovery. Play type is characterized by stratigraphically-trapped lowstand shoreface shelf margin sandstones in lower Nanushuk Formation.

UNDEVELOPED NANUSHUK-TOROK OIL

Formation	Accumulation	Location	Explorer
Nanushuk Fm	Pikka	State/ASRC onshore	Armstrong/Repsol
“ “	Willow	NPRA onshore	ConocoPhillips
“ “	Umiat	NPRA onshore	US Navy
“ “	Simpson	NPRA onshore	US Navy
“ “	Fish Creek	NPRA onshore	US Navy
Torok Fm	Nuna-Moraine	NPRA onshore	Caelus, ConocoPhillips
“ “	Cassin	NPRA onshore	ConocoPhillips
“ “	Smith Bay	State waters	Caelus

CLOSELY RELATED BROOKIAN PLAYS

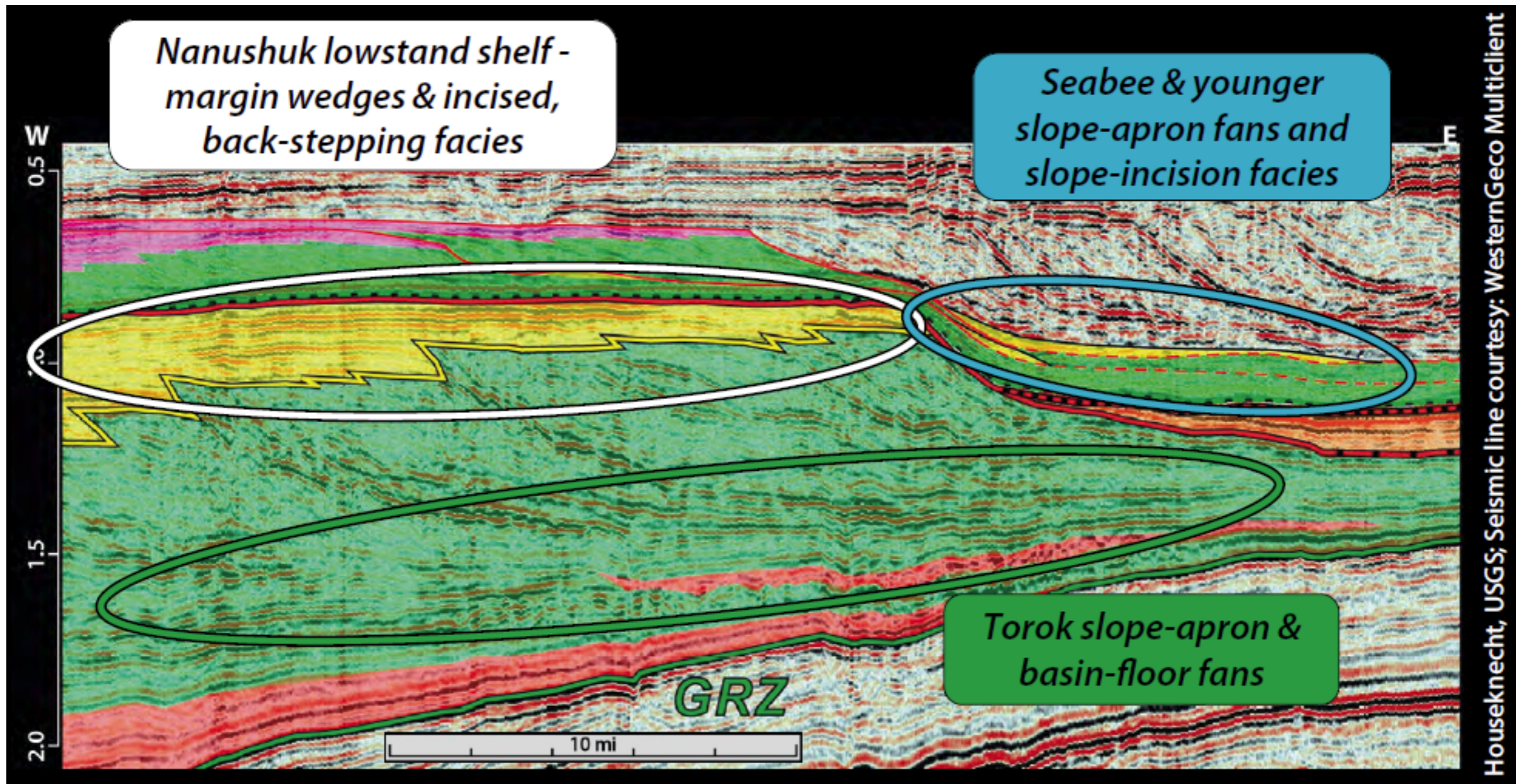


Image from David Houseknecht, USGS; courtesy GeoExpro and Western-Geco Multiclient

UNDISCOVERED RESOURCES

- USGS and BOEM estimate Arctic Alaska's mean undiscovered, technically recoverable conventional resources at nearly 40 billion barrels of oil and 207 trillion cubic feet of gas.
- The most recent assessments of North Slope onshore areas (state lands, NPRA, and ANWR coastal plain) estimate total mean resources of 15.9 billion barrels of oil + NGL.
- Of this, various Brookian plays account for 11.7 billion barrels (mean), of which 2.6 billion barrels is assessed on central North Slope state lands.
- The Nanushuk topset play of the central and western North Slope is more prospective than these assessments recognized. For example, at 300 million barrels recoverable, the Willow discovery far exceeds even the upside (F5) estimate for the Stratigraphic Brookian Topset play in NPRA.

