#### Palynological and Core Data Suggest Middle-Late Turonian Age for the Avak Impact, Barrow, Alaska\*

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#### **Abstract**

The Avak impact feature in northernmost Alaska is an integral part of the trapping mechanism for the South, East and Sikulik pools of the Barrow Gas field. The pools are at the periphery of the impact rim. The gas production comes from the Lower Jurassic Barrow sands at the base of the Kingak Formation. Logs and cores show that the upper and lower Barrow sands are coarsening upwards shoreface parasequences and that the sand-rich facies are restricted to the Barrow Arch area.

Barrow Field peculiarities include shallow burial depths (<2,250 ft.), approximately 55% water saturation, and reservoir temperatures between about 55 and 65 degrees F. Gas geochemistry (Pixler Plots) show that the gas at Barrow is comparatively dry; drier than other North Slope gas pools. Reservoir studies show the East Barrow Field is within the methane hydrate stability field and that hydrates contribute to the gas charge. The East Barrow Field also initially had anomalously high Helium concentrations which may be related to the impact origin from deep seated faulting.

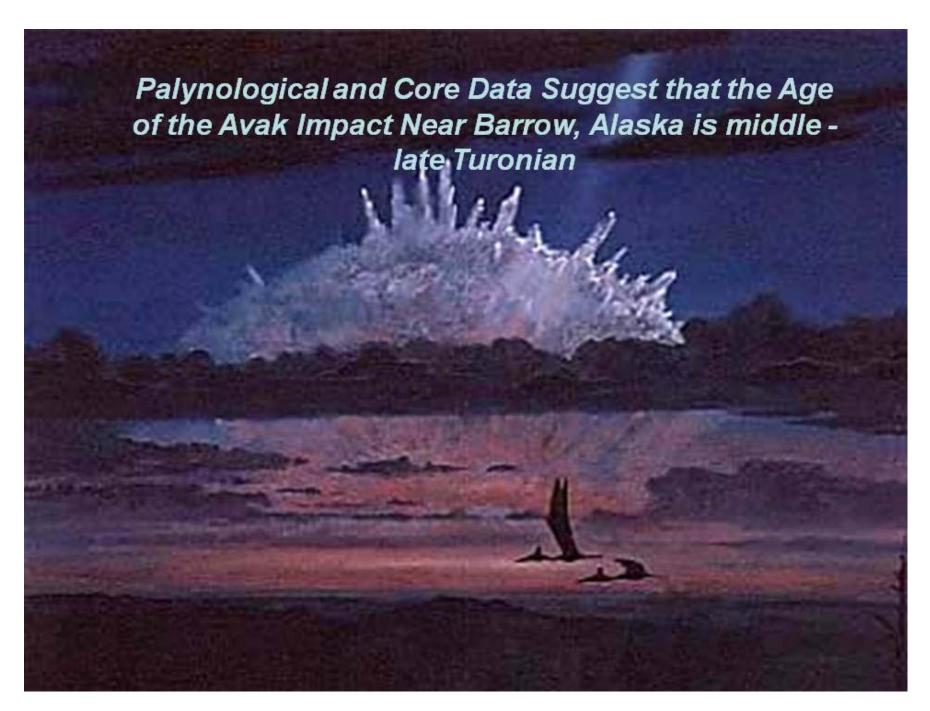
Core data from the Avak well, which is at the center of the Avak impact and between the East and South pools, shows uplifted, out of sequence and disrupted stratigraphy, shatter cones and shocked quartz which is typical of impacts. Basement lithologies, Barrow sand and Pebble Shale clasts have been found and described from several of the Simpson Core test wells which are 50 to 70 km southeast of the Barrow Gas Field. These macroscopic exotic clasts are found in the Seabee mudstones. These clasts appear to be ejecta from the Avak impact. Palynological analyses of the core matrix and clasts suggest the Avak impact occurred in the middle to late Turonian.

<sup>\*</sup>Adapted from oral presentation at AAPG Convention, Denver, Colorado, June 7-10, 2009

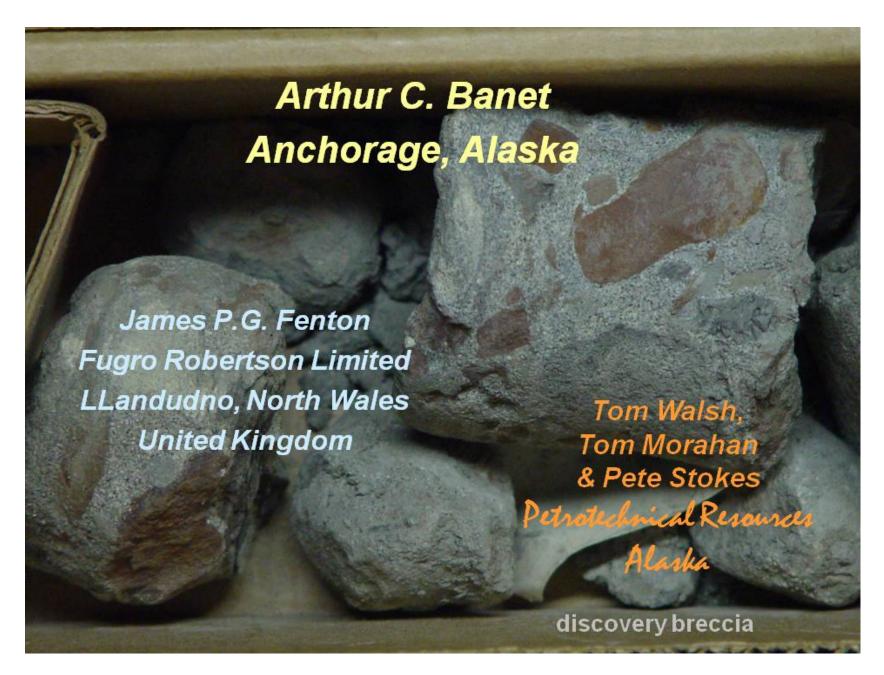
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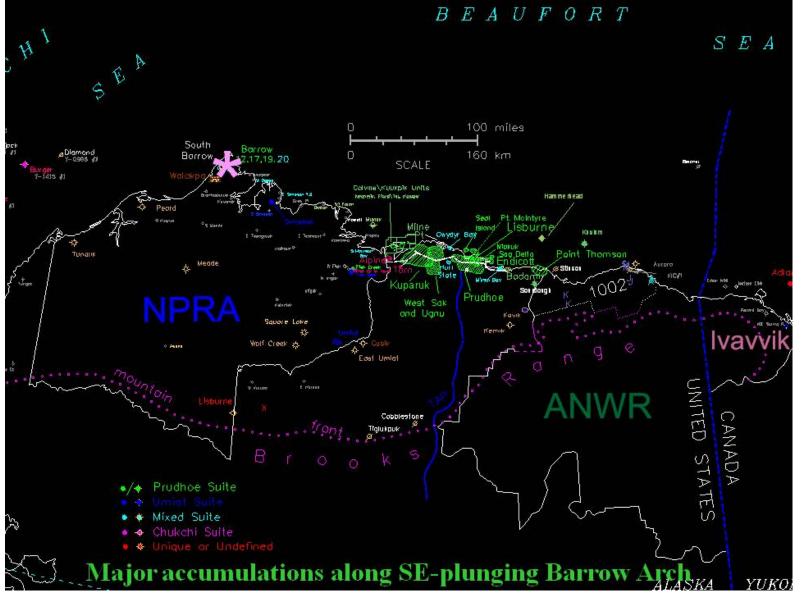
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Notes by Presenter: Showing artists rendition of a Cretaceous-aged impact, likely a marine impact.



Also shows the 'discovery breccia'. Breccia was noted in the original core descriptions. However, no connection was made in its relation to the Avak impact. It wasn't until several days or weeks after I viewed the breccia that I saw similar polymict breccia from other impacts. Consequently, I went on to examine more cores.

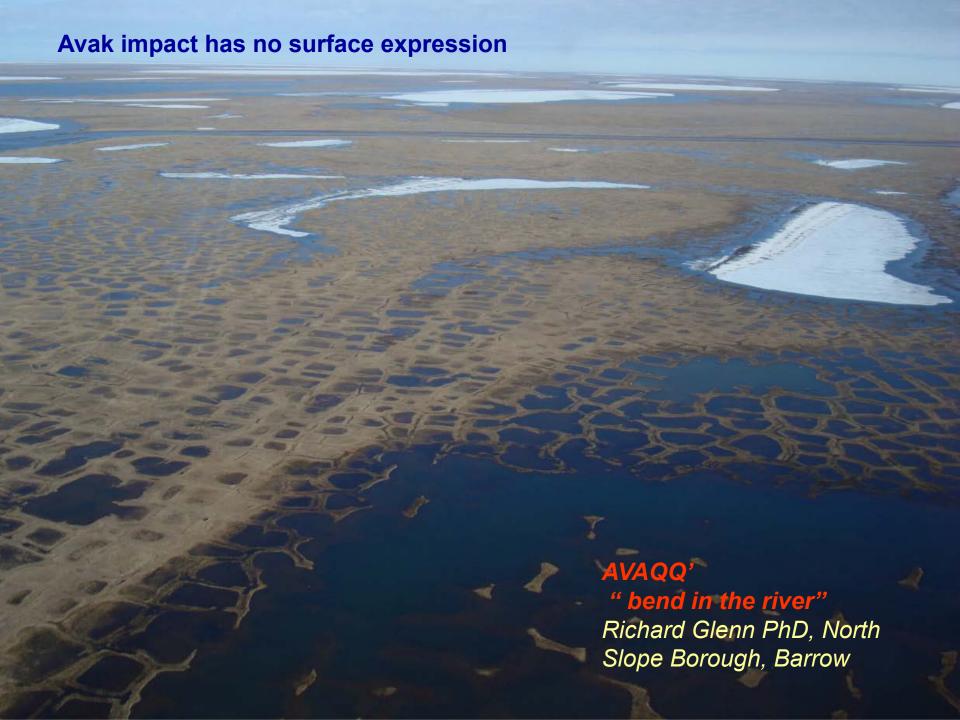


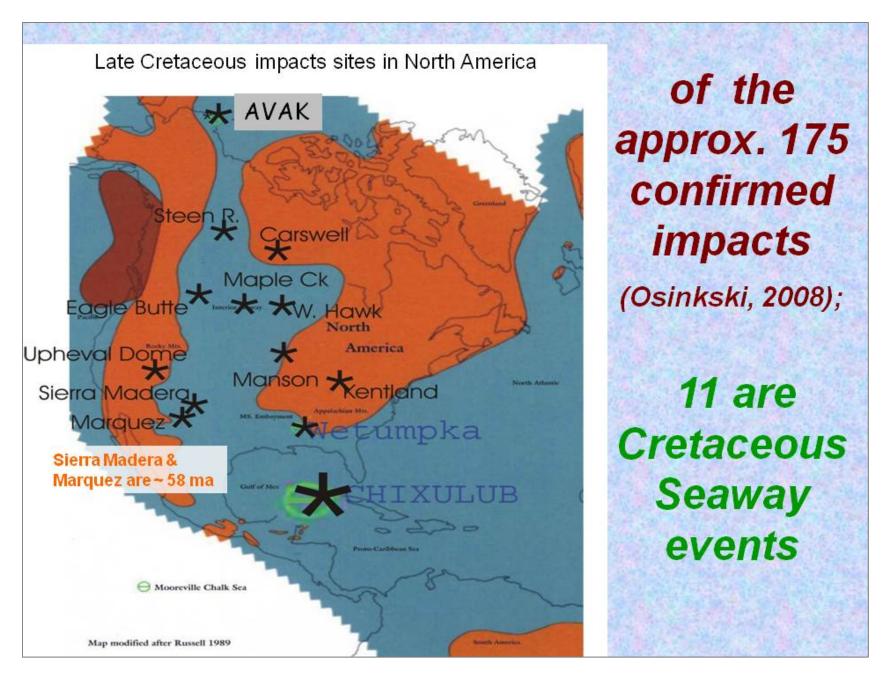
Notes by Presenter: This map shows the geographic distribution of major land entities across the North Slope. Avak is highlighted by the pink star.

NPR-A, the petroleum reserve, is managed by BLM. It is approximately 23 million acres. ANWR is managed by the Fish and Wildlife Service. It is 19.6 million acres and the coastal plane area designated by section 1002 of ANILCA is about 1.5 million acres, including the 135,000 acres of the Kaktovik Village selection.

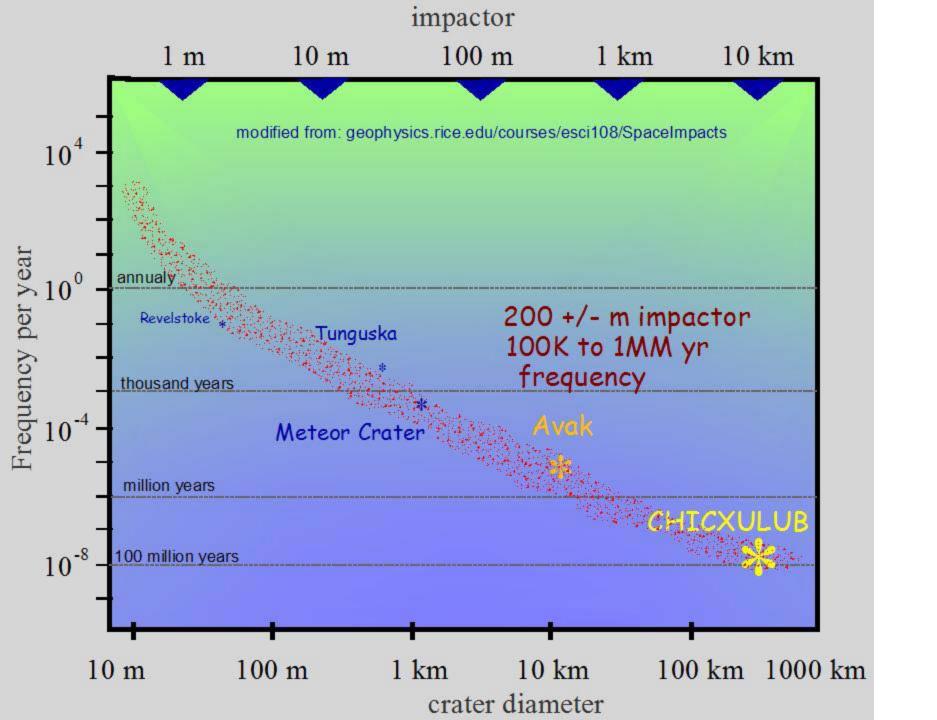
The Central Arctic area is managed by the State of Alaska. This is where oil and gas development is currently underway.

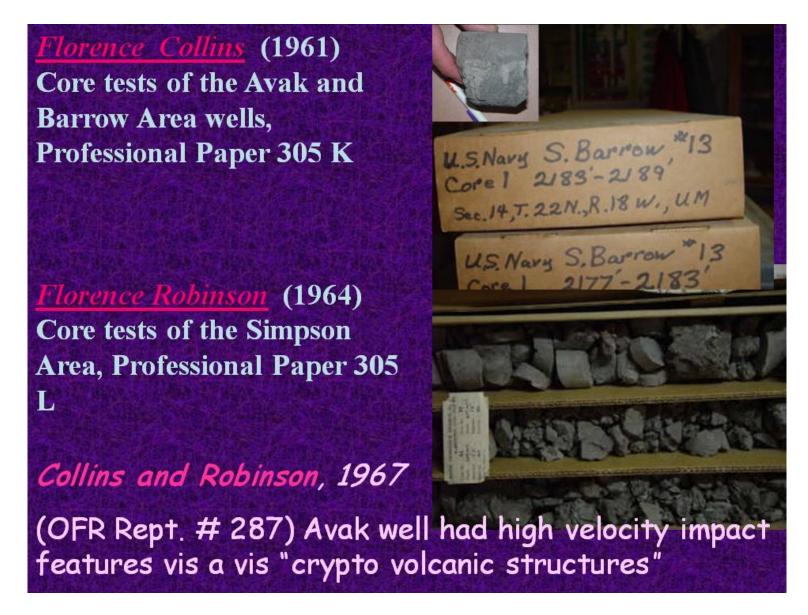
The subsurface extent of the fields is shown. Surface disturbance is about 12,000 acres in gravel roads, drilling/production pads and pipelines. About 0.3% of the surface area of subsurface extent of a discovery is affected. Colors of the various drill sites refer to differences in the chemical composition of the oil or the presence of gas at that location.





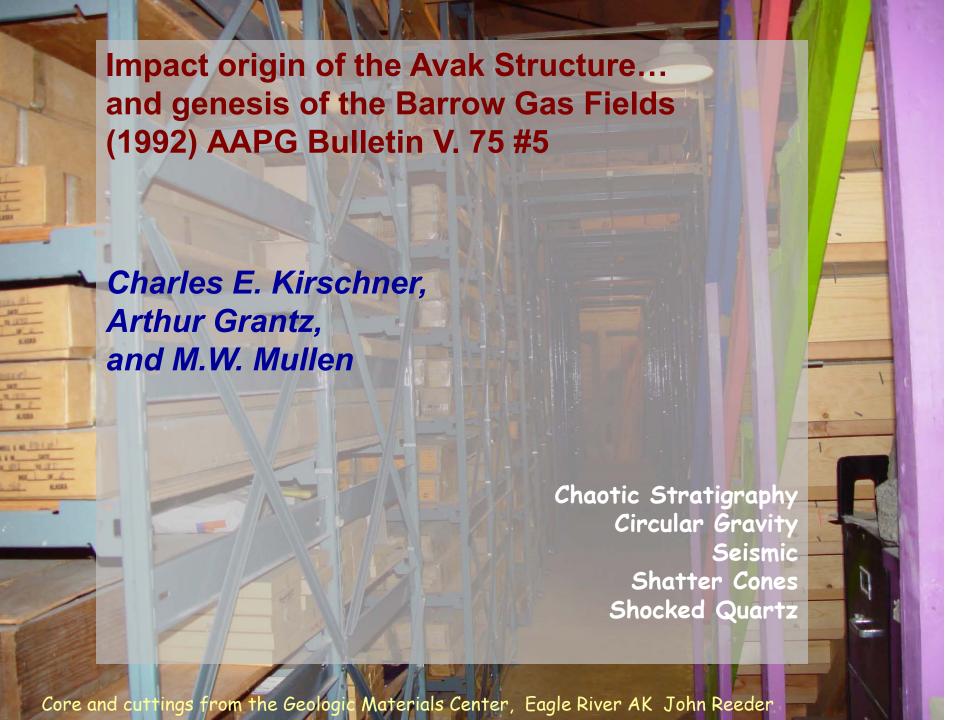
There are about 150 documented impacts. Of these, 11 are along the North American Cretaceous Seaway. Avak is the northernmost of these. Its size is less than the average size of these particular impacts. Even when the Chicxulub impact is not considered, Avak is still smaller than the average.

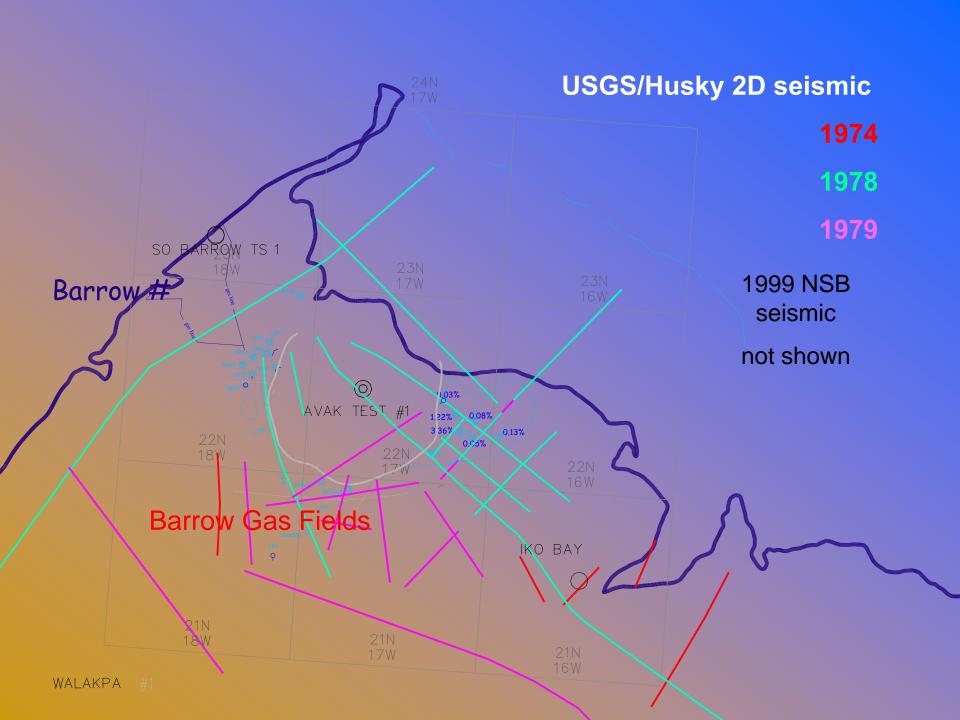


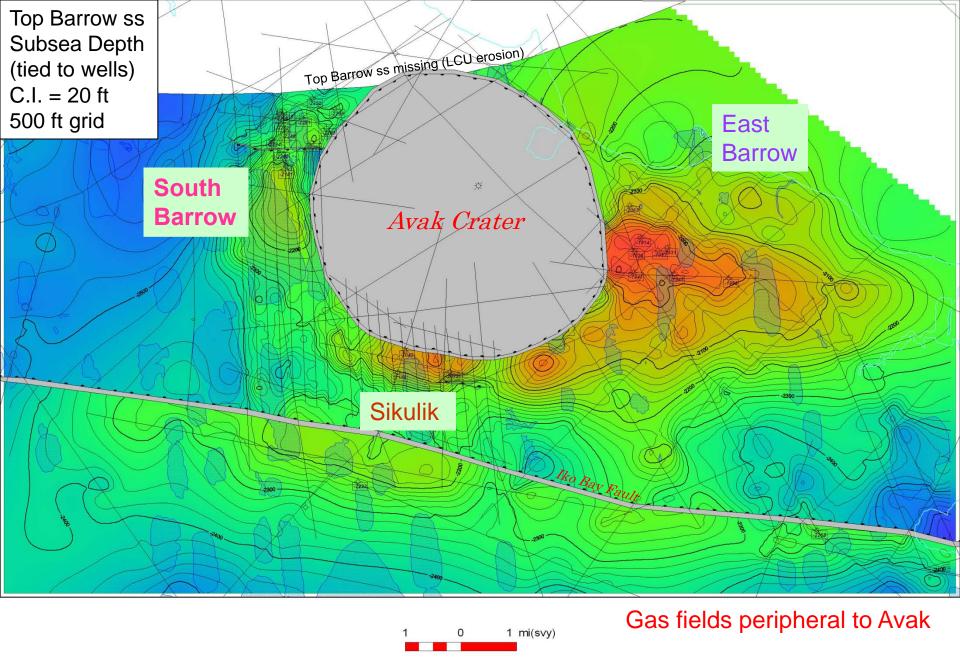


Florence Collins and Florence Robinson described the cores from the USN drilling at the Barrow Area, including the Avak well and the 31 core test holes from the Simpson peninsula. Breccia was described at both the Avak and Simpson wells.

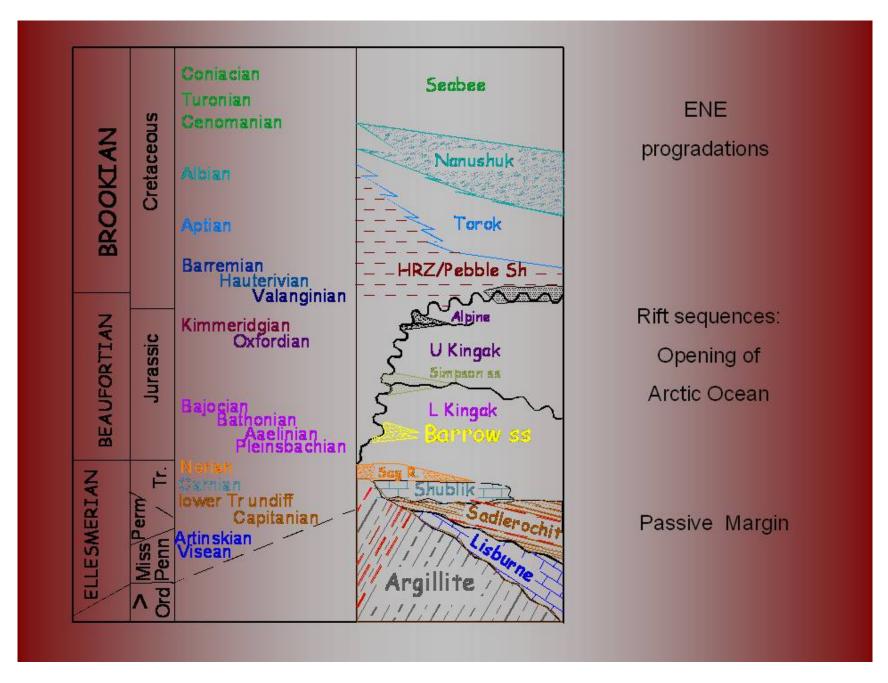
They both collaborated in a 1967 paper which suggested the oddities in the core from the Avak well were similar to features resulting from hyper velocity impact features....the same features which were more normally called crypto-volcanic features. However, no connection was made to the breccia from the Simpson area.



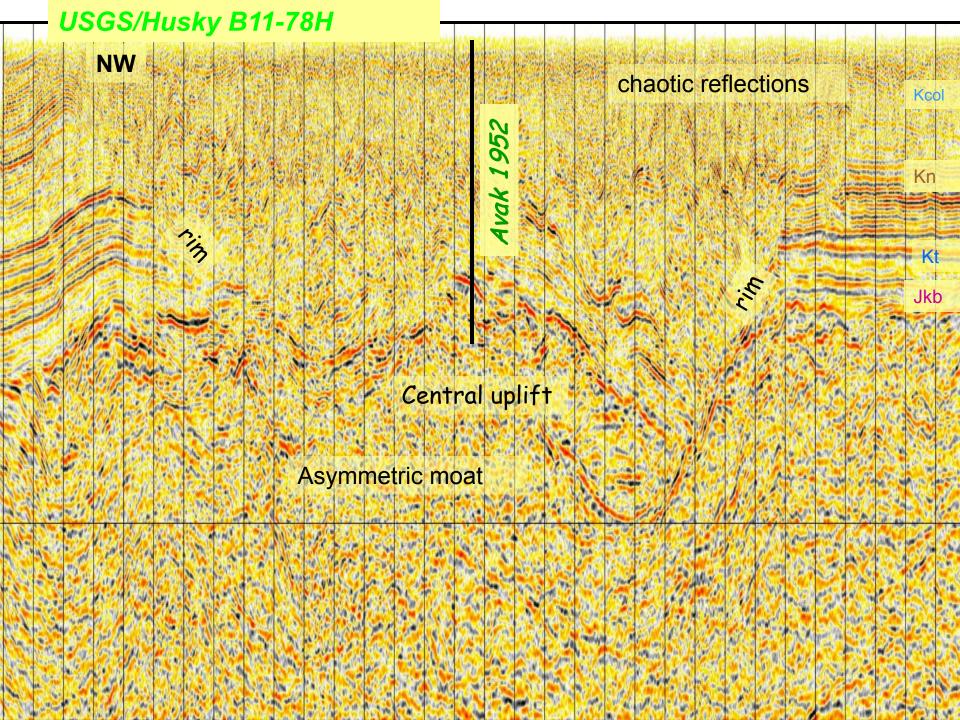




**Map from Petrotechnical Resources** 



A stratigraphic section for the Barrow Simpson area shows the Sadlerochit and Lisburne sections are truncated at this area. The section also illustrates the major sedimentary section and unconformities.



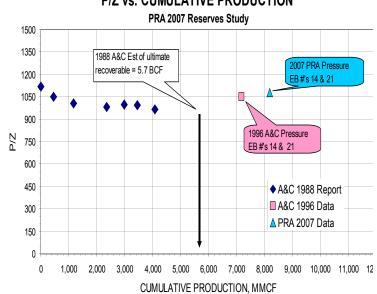


# North Slope Borough – DOE/NETL Barrow Methane Hydrate Project

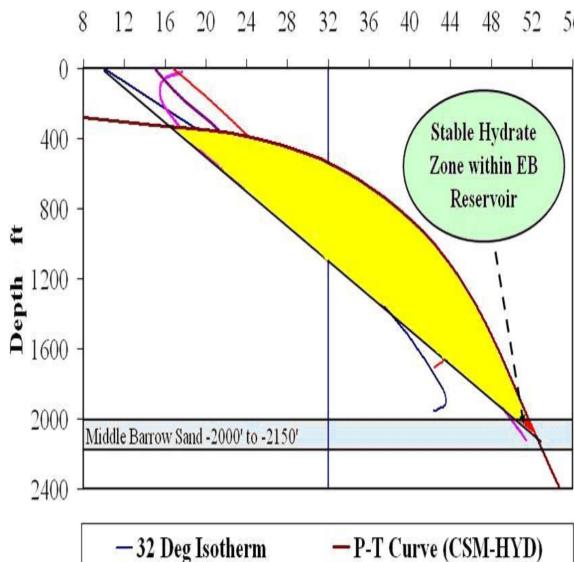
Petroteboesl Resources

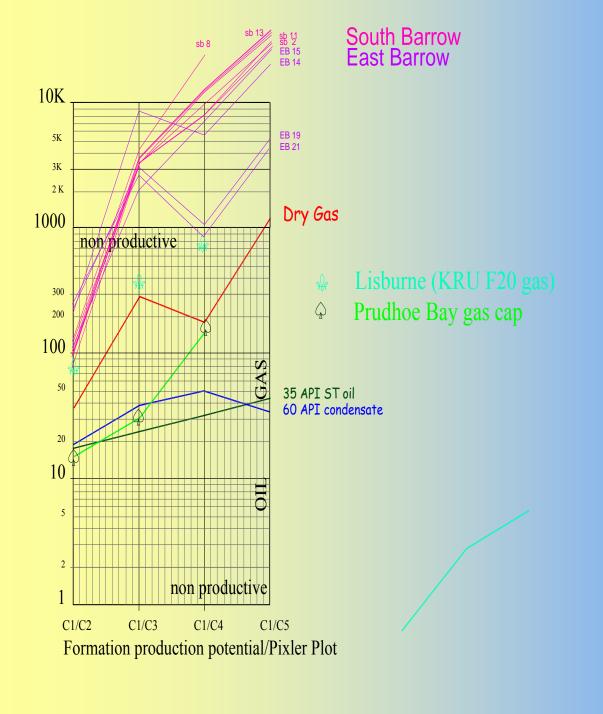
East Barrow Field

P/Z vs. CUMULATIVE PRODUCTION



## Hydrate Stability Zone for East Barrow Gas Reservoir Temperature (F)





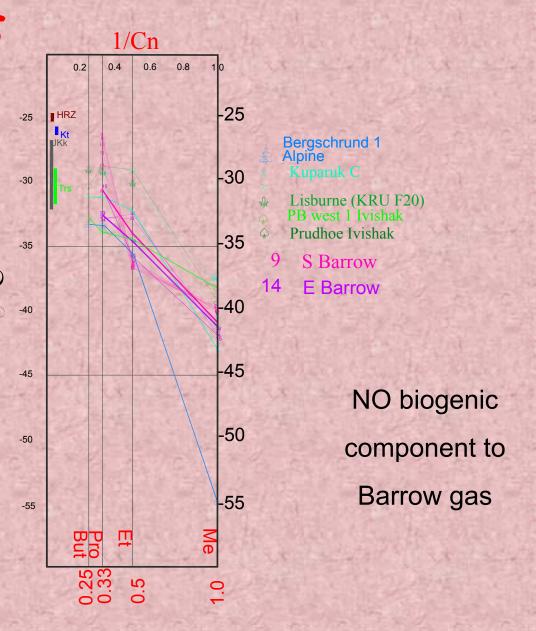
Barrow gas is dry: Verrrrry

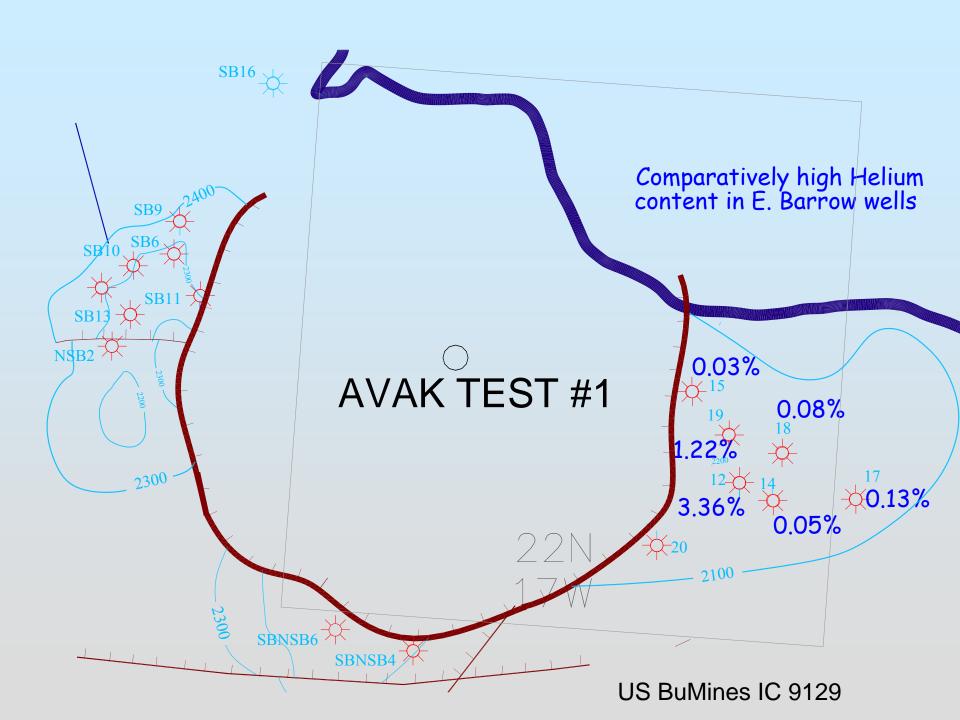
dry

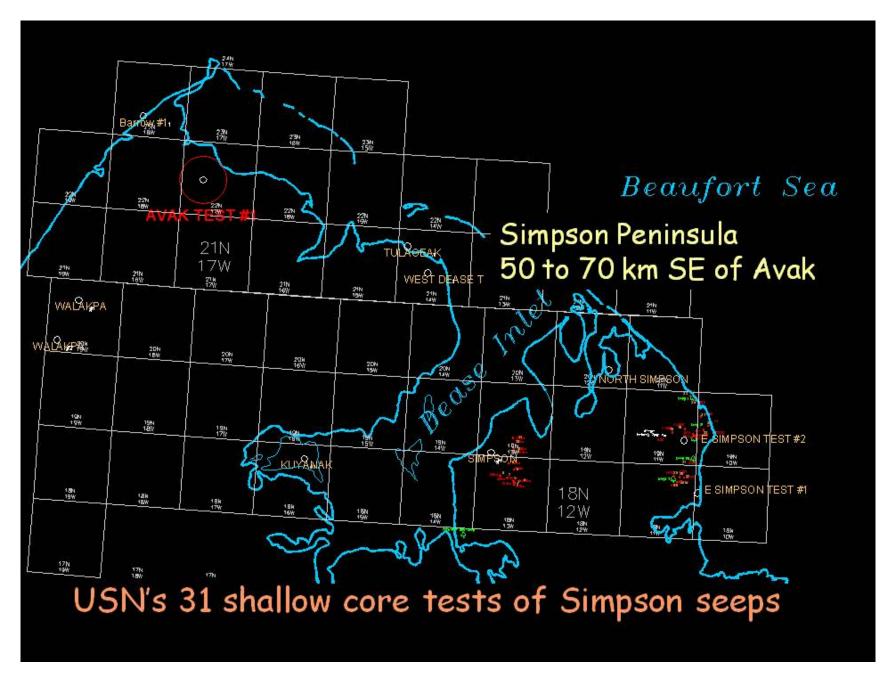
## LIGHT GAS ISOTOPES

S Barrow:
Thermal alteration
Source masked

E Barrow:
typical thermal
regime
Shublik-sourced



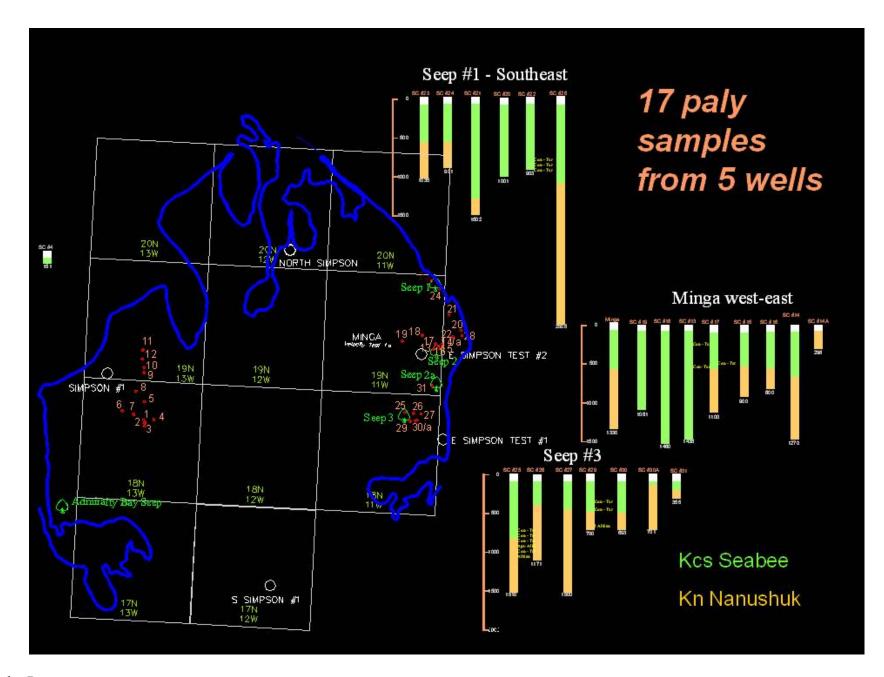




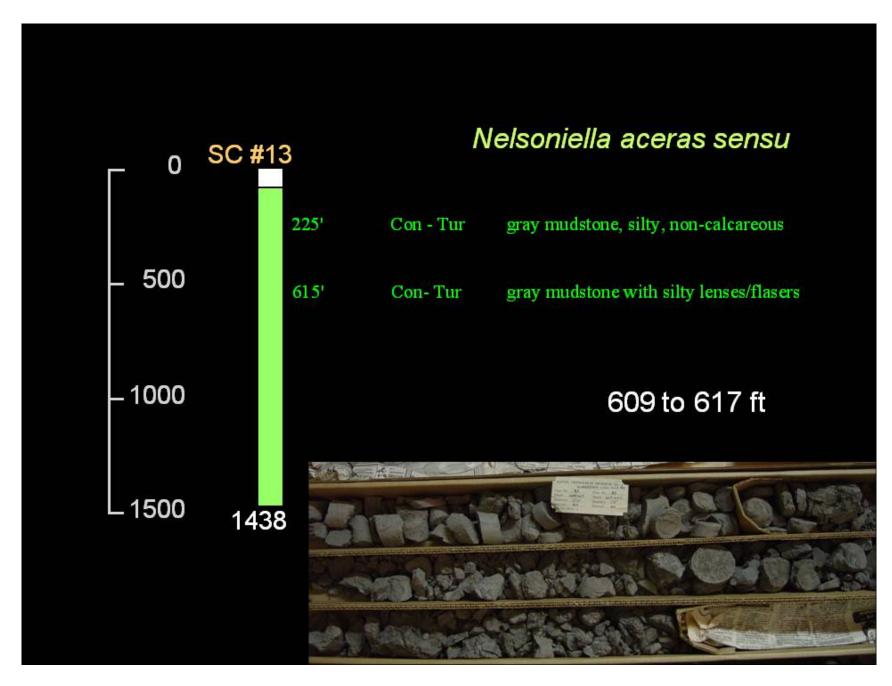
The Simpson area is 50 to 70 km east of the Avak impact. The US Navy drilled 31 comparatively shallow core tests in this area, trying to prove up the extent of these oil seeps.



The Simpson oil seeps are the most extensive on the North Slope. Their presence led the creation of the National Petroleum Reserve, which led to the USN drilling in the 1940's and 50's. This predated the Prudhoe Bay discovery in 1969. Seepage from the seeps may be as high as 1,000 bbls of oil per year.

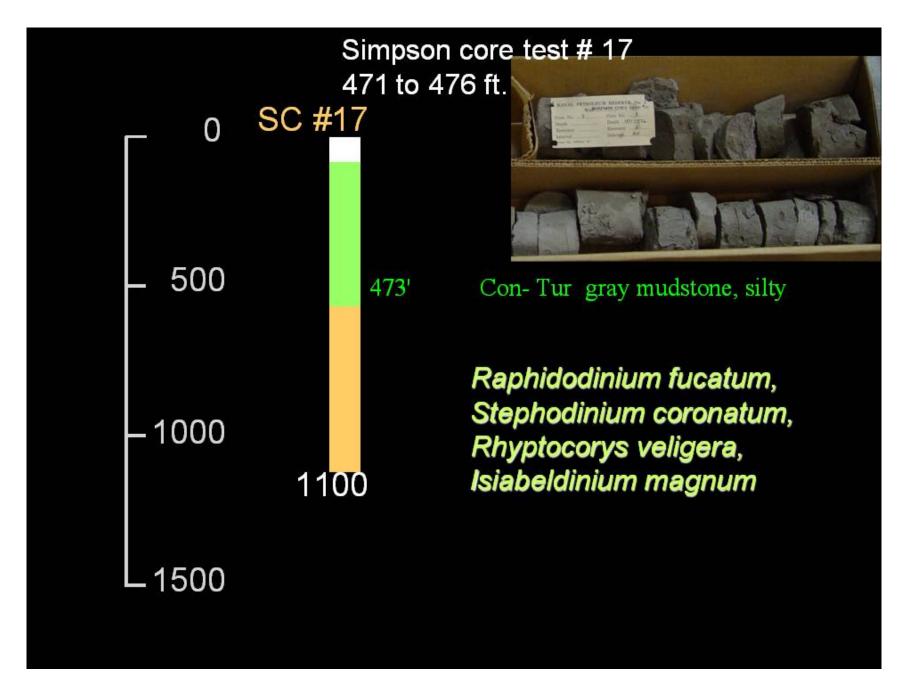


The east side of the Simpson peninsula has more drilling. These wells are deeper than those along the west side. Hole spacing is about 1 km. I have three sections; from seep #1 to the southeast, from the Minga velocity test well to the east, and the area around Seep #3. From 5 of these wells, I have 17 paly analyses. This provides paly data from a comparatively large area and also provides paly data from above and below the breccia layer.

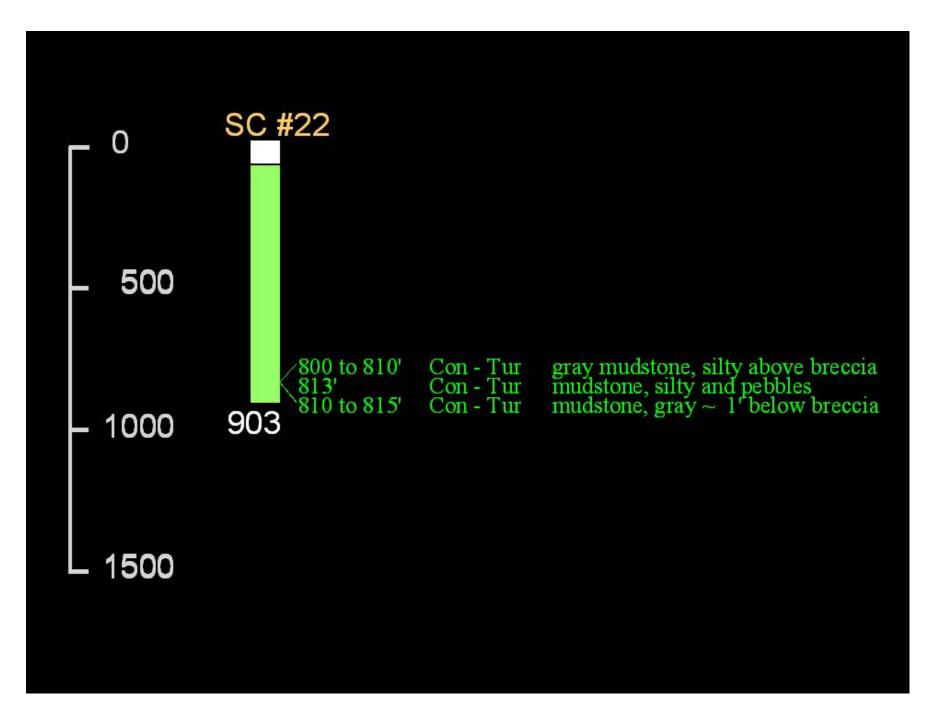


Notes by Presenter:

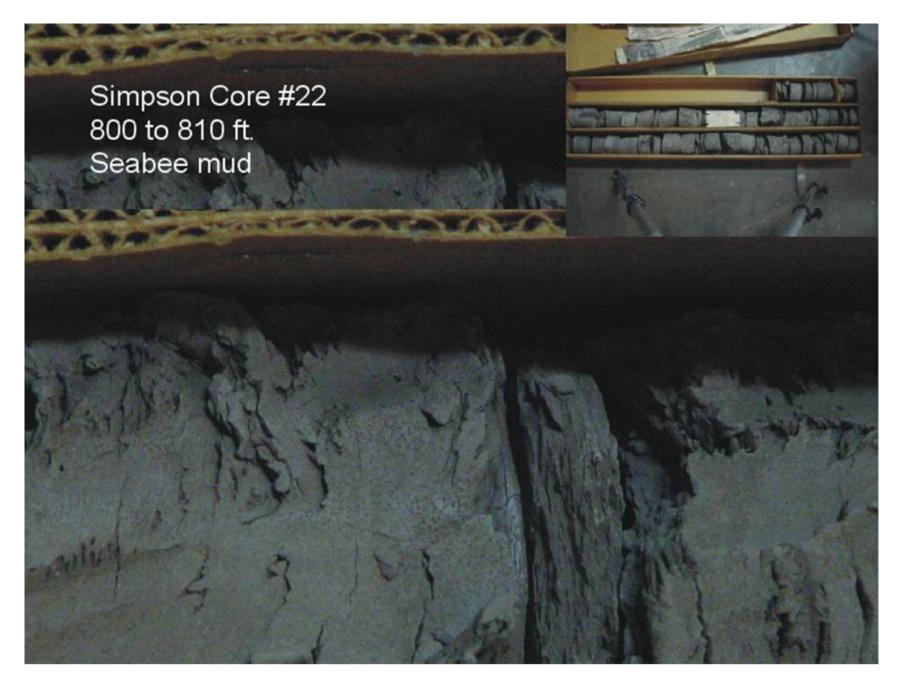
The core from this well are consist of gray mudstone. Note that the deeper core is pervasively broken. Paly shows the deeper core has a Turonian to Coniacian age.



The core from Core Test # 17 is well preserved and intact. The lithology is gray, silty mudstone. Paly shows this sample was taken near the contact with the Nanushuk. Its age is Turonian to Coniacian.



Simpson Core Test #22 was sampled immediately above the breccia layer, within the breccia and immediately below the breccia.

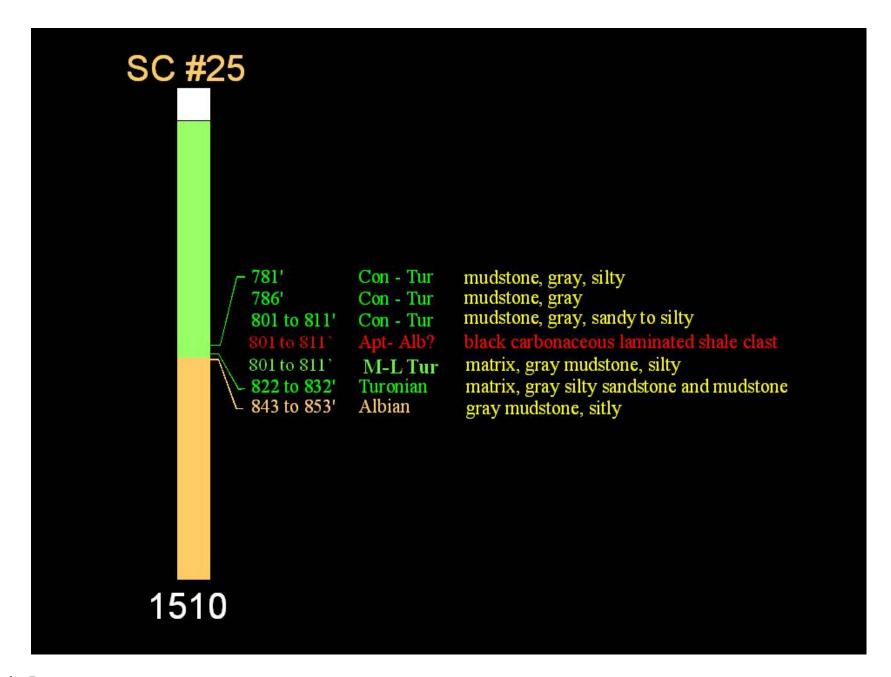


Notes by Presenter:

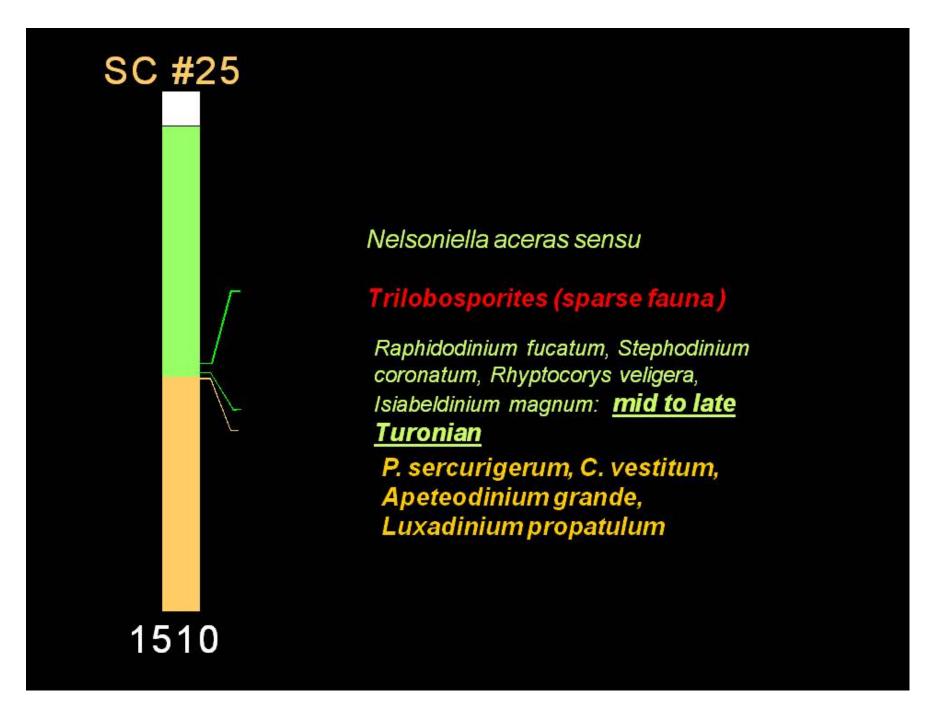
The section immediately above the breccia layer consists of gray mudstone, typical of shelf sedimentation. Core preservation is good (inset shows the entire box). The core is 2" core and the mudstone is gray, with perhaps a hint of lamination.



The breccia layer (810 ft to 815 ft.), shows there are megascopic and polymict clasts. These clasts are rounded to semi rounded and show no consistent orientation within the core. From this vantage, two clasts are reddish to brown well indurated siltstone or argillite. There is also a gray limestone clast. Note the interpenetration of the limestone and siltstone clasts. The matrix differs from the overlying soft mudstone section. The breccia matrix is indurated and has a high silt content.

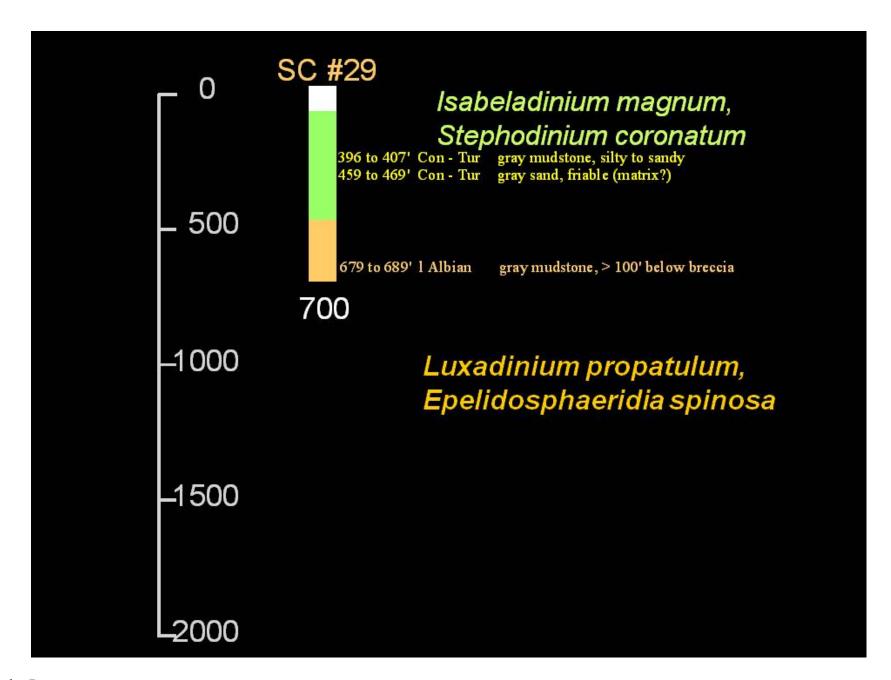


Samples from above the breccia layer consist of gray silty mudstone. These have a Turonian to Coniacian age. A clast within the breccia layer has an Aptian to ?Albian age, the matrix immediately below the exotic clast has a mid to late Turonian age. This is the only age from the Seabee samples which is restricted to mid and upper Turonian age.





This is the exotic clasts which has the Aptian age. Lithologically, black shale with its floating quartz grains (white specks) clast appears to be from the Pebble shale unit (also called Kalubik). It underlies the black platy shale of the HRZ unit. The age is consistent with this interpretation. Note the matrix is very silty mudstone and indurated, with common black and white grains.



Simpson Core test #29 has three samples. The upper sample is gray mudstone with exotic clasts. The black platy shale clast is similar to the HRZ as it is seen at outcrops on the North Slope (These outcrops are not common.). The middle sample is from the breccia layer. The deep sample is from the Nanushuk.



Notes by Presenter:

Two clasts from the shallow sample are black shales floating in a very silty gray mudstone. The mud matrix also has several floating grains within it. The black platy shale appears to be from the HRZ.

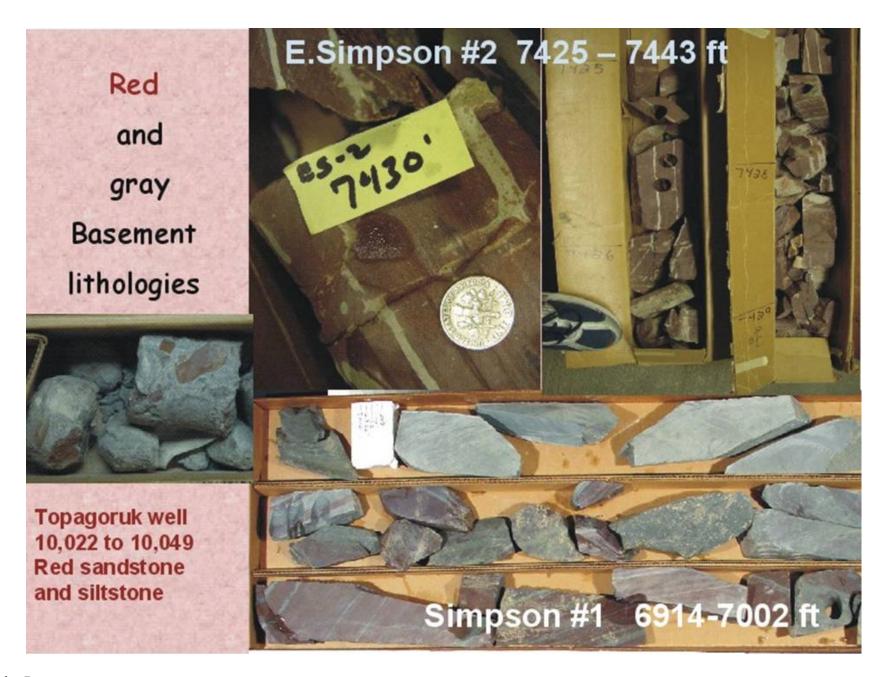


This is the discovery breccia. It features a diverse assemblage of exotic clasts in a fine to medium and poorly sorted, litharenite matrix. The grains include quartz, black and white chert and argillite. The matrix is slightly indurated. The megascopic clasts include a reddish brown well indurated silstone/argillite, gray argillite, sandstone and some gray limestone. The clasts are angular to rounded, poorly sorted and show no preferred orientation.



Notes by Presenter:

The Avak well also has reddish brown argillite floating with gray argillite, and limestone clasts within the black matrix. These closely resemble the clasts in Core tests #22 and #29.



The reddish brown argillite facies has been cored at the Simpson well and at the E. Simpson #2 wells. It also occurs in cuttings descriptions of basement rock penetrations along the Barrow Arch. The GMC does not have all of the core from the Topagoruk well. The reference is from the well's lithologic log.



# CUTTINGS & MUDLOG DESCRIPTIONS OF 29 WELLS IN AND AROUND NPR-A SHOW ANOMALOUS/ 'EXOTICS' IN SEABEE SHALE

#### S. HARRISON BAY

1350-1530

intb'd clst/bentonite and chert pebble stringers tuff? On litho log; base of Col∨ille ~3200'

#### E. SIMPSON #2

400-930

limestone, gray argillitic, silty-very silty sand, interbedded with gray limestone ck for coal partings/black carb lamina

#### N. KALIKPIK

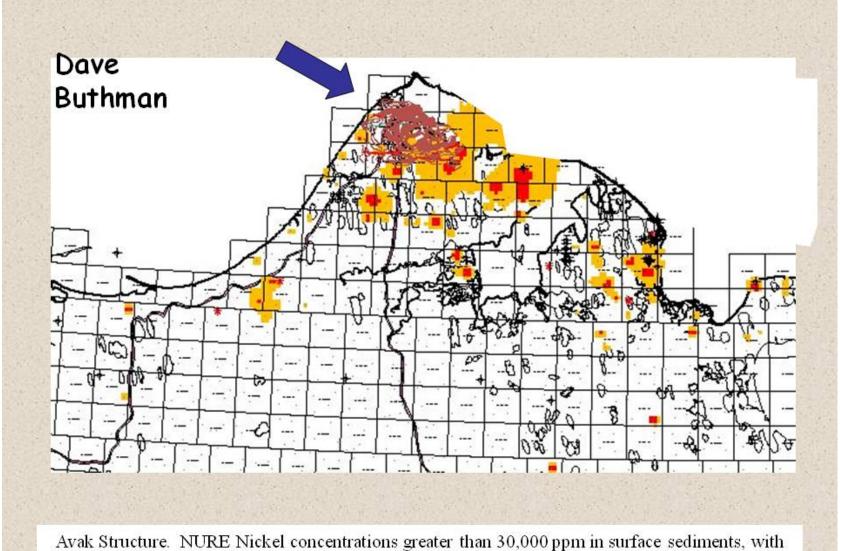
1700-2300 limestone stringers It gray shale matrix 1720-1728-most prominent





#### Notes by Presenter:

However, an examination of 29 wells shows there are anomalous clasts which occur in the Seabee across the northern portion of the NPRA. These consist of gray limestone and argillite within the mudstone of the Seabee. In addition there are several types of quartz which vary in color form clear to white. There are also black rounded beads. These are less than about a millimeter in diameter. I speculate that these may be micro tektites. Similar glass beads have been noted in lithologic descriptions of various industry-drilled wells.

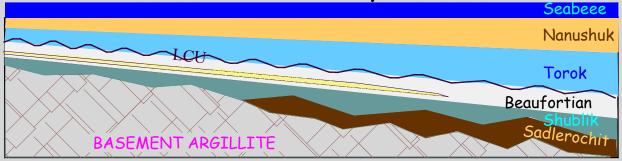


Avak Structure. NURE Nickel concentrations greater than 30,000 ppm in surface sediments, with Top Argillite Seismic Structure and wells. If the nickel is reflective of nickel-iron meteoritic material responsible for the impact, then the trajectory was from the northwest.

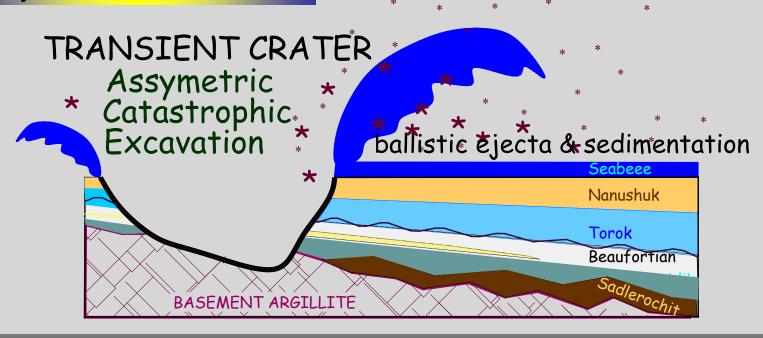
#### Notes by Presenter:

Dave Buthman supplied this slide. It shows the surface nickel concentations from the NURE program (Federally funded uranium resource program). The nickel concentrations show there is a continuous halo around the Avak site. It becomes discontinuous further away from Avak. The east side of the Simpson peninsula shows particular Ni enrichment.

mid-late Turonian (Monday??)



## Impact event!!!



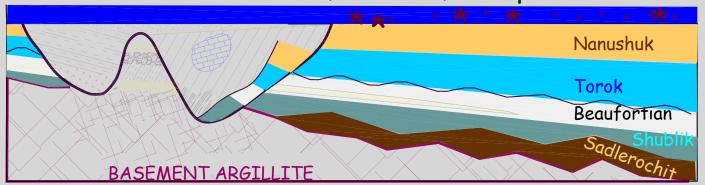
The Avak impact penetrated and ejected these same argillite/slst, shale, and limestone lithologies.

Palynology shows these clasts and impact debris occur in mid to late Turonian Seabee Shale.



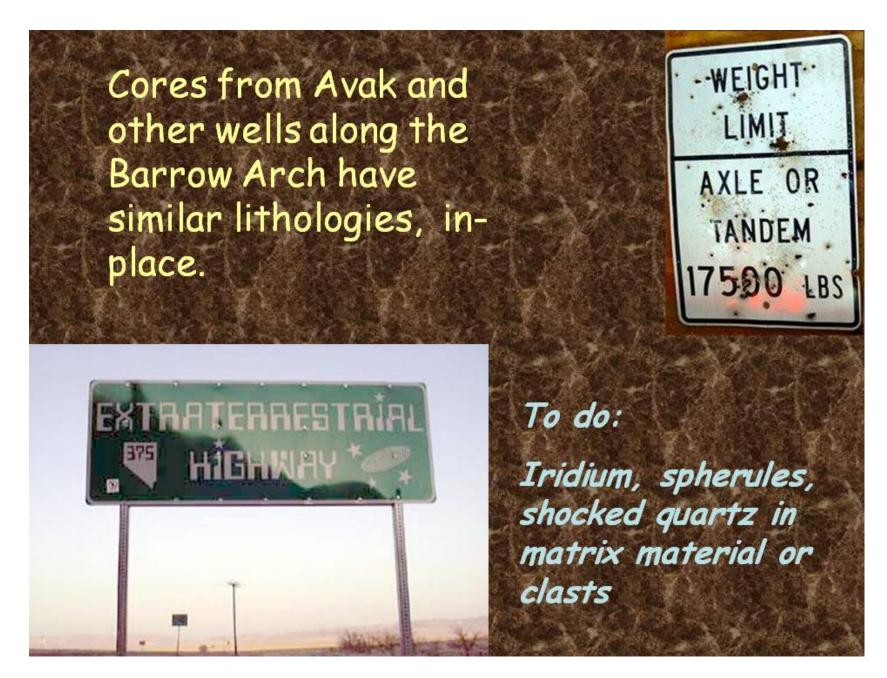
#### senesence

facies: +/-melt rock, exotics, slumped sediments

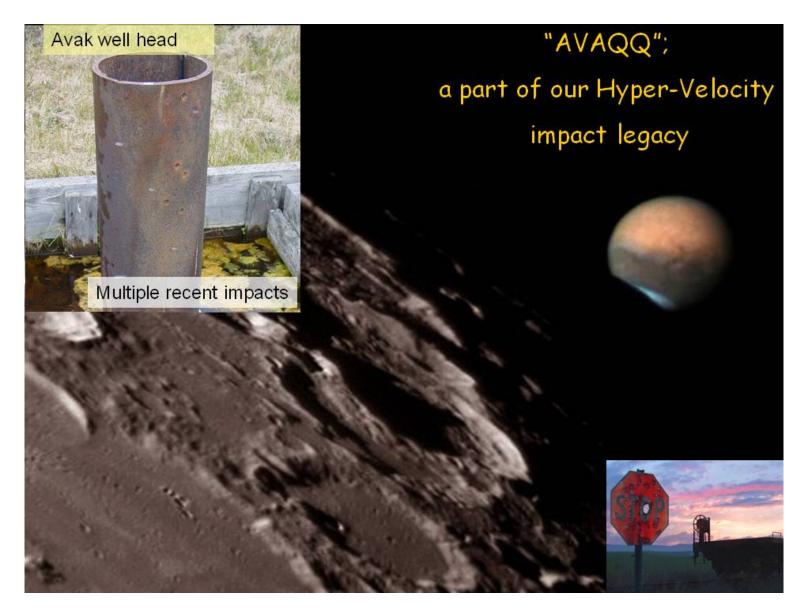




In summary, within the marine shelf mudstone section of the Seabee, there are megascopic and polymict clasts. (reddish brown argillite, black shale, gray limestone and dark gray argillite)



Examinations and descriptions of clasts from cores of the Avak well show similar clasts occur within the central uplift of the Avak impact. These same lithologies also occur in other wells along the Barrow Arch. Cuttings descriptions of the correlative Seabee also show similar lithologies occur in the cuttings samples.



Notes by Presenter:

Avak which once was a geologic curiosity with several suggested interpretations has been demonstrated as a hyper-velocity impact feature. Recognition of impact-related features such as ejecta breccia will likely show them to be common to our geologic record.

Paly data from the matrix containing the exotic ejecta clasts indicates the event occurred during the mid to late Turonian. It was likely an event which caused considerable regional disturbance. However, it impact is merely another facet of the geologic processes which comprise the terrestrial environment.

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