

ALASKA FEDERAL OFFSHORE
Descriptions of Geologic Plays
1995 National Resource Assessment
U.S. Minerals Management Service

BEAUFORT SHELF ASSESSMENT PROVINCE
(James Scherr and Peter Johnson)

Undeformed Pre-Mississippian Basement Play (UABS0101): The Undeformed Pre-Mississippian Basement Play consists of stratigraphic traps in carbonate or sandstone reservoirs in the pre-Mississippian basement complex (Dolton and others, 1987, p. 238). Leaching of carbonates or carbonate cements in the sandstones may have created some porosity and fractures may enhance permeability development. Potential source rock is the overlying Hue Shale and Canning Formation which also act as the seal. No OCS wells have tested this play. In State waters Alaska State F-1 tested 2.975 MMcf/day and 152 bbl/ day of 35.3° API gravity condensate.

Pre-Devonian Play (UABS0200 ¹): The Pre-Devonian Play includes platform carbonates and overlying shales of lower Paleozoic to Precambrian age in the western part of the Beaufort shelf assessment province. The source rock is either the carbonates or overlying shales. A source rock analog is the Silurian organic rich Cape Phillips shales in the Canadian Arctic Islands (Stuart Smith and Wenekers, 1977). The hydrocarbon traps are formed by anticlines, faulted anticlines, or faults. This play has not been tested nor is it seen in outcrop. It is only seen in CDP seismic profiles.

Endicott Play (UABS0401): Endicott Play includes the sandstone reservoirs of the Mississippian Endicott Group. The depositional environment is a pair of regressive and transgressive sequences consisting of swamp, braided stream, flood plain and shallow marine environments. Hydrocarbon traps are formed by anticlines, faulted anticlines, fault blocks, and unconformable truncations of Endicott reservoirs at younger unconformities. Two OCS wells, Y-0191 #1 and Y-0191 #2, unsuccessfully tested prospects in the play. Three OCS wells have penetrated the Tern Island oil field in this play. Onshore, the Endicott field with 480 million barrels of recoverable oil (Petzet, 1995) produces from this play.

¹The "UA" Code is the "Unique Assessment Identifier" for each play, and is the principal guide to GRASP data files.

Lisburne Play (UABS0501): The Lisburne Play includes the platform carbonate (limestone and dolomite) reservoirs of the Mississippian to Pennsylvanian Lisburne Group. Potential hydrocarbon traps of structural origins include anticlines, faulted anticlines, and fault block traps. Potential stratigraphic traps may be associated with porosity pinchouts, unconformity truncations or paleokarst topography at the Lower Cretaceous or other unconformities. Six OCS wells, Y-0191 #1, Y-0191 #2, Mukluk, Mars, Y-0181 (Seal Island), and Phoenix, tested prospects in the play without commercial success. The onshore Lisburne field with 200 million barrels of recoverable oil (Petzet, 1995) produces from the play.

Upper Ellesmerian Play (UABS0601): The Upper Ellesmerian Play includes the sandstone reservoirs of the Triassic Sag River Formation and Triassic to Permian Sadlerochit Group. The depositional environment is marine shelf for the Sag River Formation while the Sadlerochit Group has shallow marine, fluvial, floodplain, alluvial fan delta, and point bar sediments. Carbonates within the Shublik Formation are sometimes porous. Potential hydrocarbon traps are formed by anticlines, faulted anticlines, unconformity truncations, faults, or stratigraphic pinchouts. The play was the primary objective of 13 OCS wells including the well-known Mukluk well. Two OCS wells discovered and tested two oil fields, Sandpiper and Seal Island. There are three producing fields onshore, including Prudhoe Bay with 12 billion barrels recoverable oil (Petzet, 1995), Sag Delta North with 17.7 million barrels in place oil (AOGCC, 1991b), and North Prudhoe Bay State with 12 million barrels in place oil (AOGCC, 1994, p. 2).

Rift Play (UABS0701): The Rift Play contains locally derived clastics of the Beaufortian Sequence and Pebble Shale, mostly preserved in fault blocks (e.g., Dinkum graben) associated with an Early Jurassic to Early Cretaceous rifting event, but generally including correlative strata deposited beyond the rift zone. The reservoirs are marine and fluvial sandstones. The traps are anticlines, faulted anticlines, fault blocks, unconformity truncations, or stratigraphic terminations of reservoir beds. Potential source rocks may occur in the Shublik Formation, the Kingak Formation (especially in the lower Kingak), the Pebble Shale, and the overlying HRZ (“Highly Radioactive Zone”). The play had six dry OCS tests including Mars, Y-191, Fireweed, Antares, Mukluk, and Phoenix wells.

There are several onshore fields in the play, including Kuparuk field with 2.4 billion barrels of recoverable oil (Petzet, 1995), the Milne Point field with 220 million barrels of recoverable oil (Anchorage Daily News, 1995), the Point McIntyre field with 340 million barrels of recoverable oil (ARCO, 1993 and Petzet, 1995), and the Point Thomson field with 300 million barrels of condensate (Thomas and others, 1991). Three fields are in NPRA, the South Barrow field with 25 billion cubic feet of recoverable gas (Thomas and others, 1991), East Barrow field with 12 billion cubic feet of recoverable gas (Thomas and others, 1991), and Walakpa gas field with 30 billion cubic feet of recoverable gas (AOGCC, 1991a, p. 54).

Brookian Faulted Western Topset Play (UABS0800): This play includes Cretaceous deltaic topset facies of the Nanushuk and Colville Groups extending seaward from the hinge line fault zone to the province boundary. Reservoir quality is likely to be poor due to the distance from the sediment source and the high clay content associated with a mud-rich delta. Sands may thicken

abruptly in downthrown fault blocks. Source rocks are primarily gas-prone shales of the Torok Formation and Colville Group. Rotated blocks along listric growth faults are the chief trapping mechanisms. No prospects have been tested in the play area.

Brookian Unstructured Western Topset Play (UABS0902): This play occurs in the deltaic topset facies of the Brookian Sequence, primarily the Nanushuk Group, in the area between the Barrow Arch and the offshore hinge line fault zone. The Nanushuk Group in the play area is likely to be a poor reservoir due to the high clay content of the deltaic sandstones found in wells in the area. Potential source beds include the underlying Torok Formation, the Pebble Shale, the Kingak shale and the Shublik Formation. These sources may generate oil and/or gas. The play area is sparsely faulted and the sequence dips homoclinally to the north. Prospects are primarily stratigraphic traps related to the pinchout of reservoir beds. Prospects in this play have not been tested in the offshore. Sub-commercial oil pools onshore include the Simpson (12 MMBO recoverable) and Fish Creek (no resource estimate) fields in the National Petroleum Reserve-Alaska (Thomas and others, 1991 Table 2.2).

Brookian Faulted Western Turbidite Play (UABS1000): This play includes Cretaceous prodelta facies of the Torok Formation and lower Colville Group. Expected reservoirs include lowstand wedges or turbidite sands in submarine fan environments. Sandstone sequences may thicken abruptly in down thrown blocks in the hinge line fault zone. As in the Brookian Unstructured Western Turbidite Play (UABS1102), the reservoir sands are likely to be poor quality due to the fine grained nature of the Nanushuk deltaic system that delivered sand to the shelf break. Shales in the Torok Formation and Colville Group are primarily gas sources due to kerogen content and because many thousands of feet of the shales have passed through the oil window and into the gas window. Traps in the play are expected to be primarily stratigraphically controlled. There is also potential for fault traps against hinge line listric growth faults. No prospects have been tested in the play area.

Brookian Unstructured Western Turbidite Play (UABS1102): This play includes the Lower Cretaceous prodelta facies of the Torok Formation in the lower part of the Brookian sequence. It mostly underlies the Brookian Unstructured Western Topset Play (UABS0902). Expected reservoirs include turbidite sands deposited in submarine fan environments. Reservoir quality is expected to be poor due to the fine grained nature of the Nanushuk deltaic system that delivered sand to the shelf break. The Torok Formation, Pebble Shale, Kingak shale and Shublik Formation all form potential source rocks for charging reservoirs in this play. The Kingak shale in this area may be oil prone, but probably reaches sufficient thermal maturity only in rift grabens with expanded sedimentary thicknesses. Prospects are primarily stratigraphic traps formed by sand mounds within a shale sequence. The Phoenix well tested heavy oil in the Torok Formation and the Mukluk well had several Torok Formation oil shows.

Brookian Faulted Eastern Topset Play (UABS1201): This play includes deltaic topset facies of the Tertiary Sagavanirktok Formation and the Upper Cretaceous Colville Group. It is located seaward of the hinge line fault zone across the central part of the province. The

Sagavanirktok Formation sandstones offer excellent reservoir characteristics. Potential source rocks are organic- rich marine shales within the Canning Formation that reach thermal maturity north of the hinge line in the Nuwuk and Kaktovik basins. There is also potential for oil generation from Beaufortian sequence source rocks deeply buried within the Dinkum graben. The latter source rocks have passed completely through the oil generation window. Prospects in the play are likely to be fault traps along down-to-the-north listric growth faults. Seal continuity may be a risk factor for many prospects due to the high sand content of the Sagavanirktok Formation. One offshore well, Galahad, was drilled in the play area and encountered a gas sand that yielded frothy brown oil.

Brookian Unstructured Eastern Topset Play (UABS1302): This play includes deltaic topset facies of the Tertiary Sagavanirktok Formation and equivalent facies of the Upper Cretaceous Colville Group. It is located north of the Barrow Arch and south of the hinge line fault zone east of the eastern stratigraphic limit of the Nanushuk Group (generally east of Cape Halkett). Excellent reservoir quality sands occur within the Sagavanirktok Formation in most coastal wells and we expect quality reservoir sequences to continue offshore. The Canning Formation, Pebble Shale, Hue Shale, lower Kingak shale, and the Shublik Formation are variable to rich oil source rocks that lie within the projected oil window and underlie the play sequence across most of the play area. The play sequence is sparsely faulted. Most of the prospects are expected to be stratigraphic traps or small-offset fault traps. Seals are likely to be a risk factor for many of the prospects because of the abundant of sandstone within the play sequence. Oil was discovered offshore at Hammerhead prospect (reserves not released), and Kuvlum (reserves not released) and onshore at West Sak (15-25 BBO in place; Thomas and others, 1991 Table 2-5) and Ugnu (11-19 BBO in place reserves; Thomas and others, 1991 Table 2-5). In Harrison Bay, the Phoenix well tested oil from a sandstone in the Colville Group.

Brookian Faulted Eastern Turbidite Play (UABS1400): This play includes the Late Cretaceous and Tertiary prodelta shales and turbidites of the Canning Formation located between the hinge line fault zone and the northern province boundary, east of the eastern stratigraphic limit of the Torok Formation. Reservoirs are primarily turbidite sands in a submarine fan environment. The primary source rocks are expected to be gas-prone shales of the Canning Formation. There is also a potential for hydrocarbon generation from Beaufortian sequence source rocks that underlie the play sequence. These Beaufortian rocks are likely to be buried to below the base of the oil window and are most likely fully expended with respect to oil. Prospects in the play are both stratigraphic traps related to sand mounds within the marine shale sequences, and fault traps against listric growth faults. No wells have tested the play.

Brookian Unstructured Eastern Turbidite Play (UABS1502): This play includes Late Cretaceous and Tertiary prodelta shales and turbidites of the Canning Formation. It is located on the relatively unstructured part of the shelf between the Barrow Arch and the hinge line fault zone east of the eastern stratigraphic limit of the Torok Formation (east of the Colville River delta). It underlies much of the Brookian Unstructured Eastern Topset Play (UABS1302). Reservoirs include turbidite sands in submarine fan environments enclosed in prodelta shales.

Source rocks include relatively gas-prone shales of the Canning Formation, and rich oil-prone shales of the Hue Shale and Pebble Shale units. The base of the play sequence lies in direct contact with these source beds. Stratigraphic traps predominate, although small scale fault traps also occur. Marine shales provide a good seal for trapping hydrocarbons. The OCS Y-191 (Beechy Pt. #2) well, drilled in Steffanson Sound flowed oil and gas out of the Canning Formation. Onshore, oil has been tested in turbidite sands of the Canning Formation in the Badami field (estimated reserves, 100 MMbbl oil and 100 BCF gas; Alaska Report, 1994) and at Flaxman Island.

Brookian Foldbelt Play (UABS1602): This play includes Tertiary Sagavanirktok Formation topset sequences and Cretaceous to Tertiary Canning Formation topset and pro-delta sequences complexly structured by both Brooks Range folding and coeval faulting along the hinge line fault system. The hinge line obliquely intersects the foldbelt within the area of the Brookian Foldbelt play. Major offshore structural features included in the play are the Herschel High, the Demarcation Subbasin, and the Camden anticline. Onshore, the play includes Marsh Creek anticline and other shallow structures in the Arctic National Wildlife Refuge (ANWR). Reservoir sands are very sparse in the three offshore wells (Belcher, Corona, and Aurora) that tested prospects in this play. However in the Natsek well at the southeast end of the Herschel High in Canada, reservoir quality sands were encountered in Upper Cretaceous and Paleocene rocks. Potential oil sources include the Hue Shale and Canning Formation, which probably underlie many offshore structures in the Brookian Foldbelt play. However, wells testing the play penetrated only Tertiary shales with gas-prone kerogen. The dominant recognized trap types include anticlines, faulted anticlines and fault closures. Also likely are stratigraphic traps occurring in syn- and post-tectonic sediments which fill basins developed between folded uplifts. Late stage structuring may have destroyed earlier formed seals and traps. Three offshore wells unsuccessfully tested the play. Belcher well was drilled on an anticline on the Herschel High and encountered neither sandstones nor hydrocarbon shows. Corona was drilled on the crest of Camden anticline, and encountered only sparse thin sandstones with no hydrocarbon shows. Aurora was drilled on an anticlinal feature adjacent to the Arctic National Wildlife Refuge. It primarily encountered shales and no hydrocarbon shows in the Brookian sequence.

Beaufort Shelf Plays That Overlap with Chukchi Shelf:

Endicott Portion Shared with Chukchi Shelf (UABS1800) *Chukchi Shelf Play 2 (UACS0200).*
Lower Ellesmerian—Endicott Clastics-Arctic Platform: Reservoir objectives primarily include Late Devonian(?) to Mississippian sandstones deposited in marginal- to non-marine environments on the east side of Hanna trough during the early rift phase of subsidence. Early-formed horst and stratigraphic wedge traps have been buried to greater depths than their Chukchi platform counterparts and are associated with higher levels of thermal maturity and poorer reservoir properties. The play is charged by the Hanna trough play charging system (see Chukchi shelf play 1). Most identified prospects lie considerably deeper than the primary regional source rock (Shublik), and high thermal maturity of traps suggests the hydrocarbon endowment is largely dry gas. Chukchi shelf play 2 is therefore modeled with a higher gas content than other Chukchi shelf

plays charged by the Hanna trough play charging system. This play was not tested by any wells.

Lisburne Portion Shared with Chukchi Shelf (UABS1900) *Chukchi Play 3 (UACS0300).*

Lower Ellesmerian—Lisburne Carbonates: Reservoir objectives include Mississippian to Permian carbonates that were deposited on a stable marine shelf, with deeper water facies in the southeast part of the province in axial parts of Hanna trough. Porosity in Lisburne carbonates is associated with sparse porous zones in limestones and thin dolomite beds. No reef facies have been documented within the Lisburne carbonate assemblage, which ranges in age from Mississippian to Permian. The play is primarily charged by the Hanna trough play charging system (see Chukchi shelf play 1), with minor contributions from interbedded organically-lean and gas-prone shales. Incomplete penetrations of the Lisburne carbonates occurred at Popcorn, Crackerjack, and Diamond wells, which encountered carbonates with porosities ranging from 0 to 14%. No hydrocarbons were encountered in Lisburne carbonates in these wells.

Ellesmerian Deep Gas Shared with Chukchi Shelf (UABS2000) *Chukchi Shelf Play 4*

(UACS0400). Ellesmerian Sequence—Overmature "Deep Gas" (Lower and Upper Ellesmerian Sequences): Reservoir objectives include all potential reservoirs in both Lower Ellesmerian and Upper Ellesmerian sequences (reservoir strata described in Chukchi shelf plays 1,2,3,5, and 6). Prospects in the "Deep Gas" play occur at subsurface depths beneath the oil floor (2.0% vitrinite reflectance) and would contain only gas. High thermal maturities have a detrimental effect on reservoir properties and multi-cycle tectonic history combined with extremely deep burial at present (to 38,000 ft) result in high exploration risks for Chukchi shelf play 4. This play was penetrated at Tunalik well in northwestern Alaska with no hydrocarbons present. At the level of Lower Ellesmerian rocks, Chukchi shelf play 4 extends from Chukchi shelf province into western parts of the Beaufort shelf assessment province.

Upper Ellesmerian - Portion Shared with Chukchi Shelf (UABS2100) *Chukchi Shelf Play 6*

(UACS0600). Upper Ellesmerian—Sadlerochit Group-Arctic Platform: Reservoir objectives primarily include Late Permian to Triassic marginal to shallow marine sandstones of the Sadlerochit Group that were deposited on the south-facing shelf that then existed on the Arctic platform. Diamond well, offshore on the east flank of Hanna trough, encountered over 500 feet of potential reservoir strata that are correlative to the Permian Echooka Formation. Primary trap styles include stratigraphic wedges and fault traps, with hydrocarbons migrating northward into traps from the Hanna trough play charging system on the south. A prospect in this play was penetrated at Diamond well where it is barren of hydrocarbons. Several wells also penetrated the play sequence (with no pooled hydrocarbons) in northwestern Alaska.

Rift Portion Shared with Chukchi Shelf (UABS2200) *Chukchi Shelf Play 8 (UACS0800). Rift*

Sequence—Stable Marine Shelf: Reservoirs are primarily Late Jurassic to Early Cretaceous sandstones equivalent to the Kuparuk Formation of Arctic Alaska. Unlike the sandstones in the tectonically active rift zone (Chukchi shelf play 7) to the north, these rocks were instead deposited south of the rift zone on a tectonically stable shelf and slope that rimmed a deep water area in southernmost Hanna trough. Here, we anticipate fine-grained marine shelf sandstones that are

thinner at the extremes and probably less continuous laterally than their counterparts in Chukchi shelf play 7. This play is charged by the Hanna trough play charging system (described in Chukchi shelf play 1). A prospect within the play was incidentally tested by Klondike well, encountering pooled oil in a sandstone 80 feet thick. Diamond well encountered no sandstones (only the Pebble Shale was present) and was barren of hydrocarbons.

Sand Apron Shared with Chukchi Shelf (UABS2300) *Chukchi Shelf Play 14 (UACSI400). Sand Apron-North Chukchi High (Upper and Lower Brookian sequences):* Potential reservoirs are inferred to consist primarily of shallow marine to fluvial sandstones of Early Cretaceous to Tertiary age that are hypothesized to have been deposited in littoral systems that fringed North Chukchi high, an area of recurrent uplift throughout Albian-Aptian (post-Brookian unconformity) and later time (Johnson, 1992). This play therefore includes both Lower and Upper Brookian sequences. The play is probably charged primarily from the west by the North Chukchi basin play charging system (Lower Cretaceous to Tertiary Brookian shales generating gas and oil that rose along faults into shallow traps in North Chukchi basin and nearby structural uplifts). This play has not been tested by any well.

Turbidites (Torok) Shared with Chukchi Shelf (UABS2400) *Chukchi Shelf Play 17 (UACSI700). Lower Brookian Sequence—Torok Turbidites-Arctic Platform (Unstructured):*

This play addresses the unstructured area of the Arctic platform that lies south of Barrow arch, east of the wrench fault province of western Chukchi shelf (equivalent Chukchi shelf play 12), and north of the foldbelt (Chukchi shelf play 11). Potential reservoirs are turbidite sandstones within the Lower Cretaceous Torok Formation. Exploratory drilling has shown that sandstone is quite sparse within the Torok Formation in this play. Reservoir presence is therefore one important risk element for the play. Low-relief anticlines, possibly related to compaction, mounded fan complexes, and slope turbidites isolated within slope shales form the primary anticipated trap types, few of which are readily observable in seismic data. The play is modeled as predominately charged by the Hanna trough play charging system (described in Chukchi shelf play 1), although some contribution from the gas-rich Colville basin play charging system (described in Chukchi shelf play 11) is also possible. The play was tested by Burger and Diamond wells and several wells onshore. No pooled hydrocarbons were encountered in any well.

Topset (Nanushuk) Shared with Chukchi Shelf (UABS2500) *Chukchi Shelf Play 18 (UACSI800). Lower Brookian Sequence—Nanushuk Topset-Arctic Platform (Unstructured):*

This play addresses the unstructured area of the Arctic platform that lies south of Barrow arch, east of the wrench fault province of western Chukchi shelf (equivalent Chukchi shelf play 13), and north of the foldbelt (Chukchi shelf play 11). Reservoir objectives include delta-plain and nearshore sandstones of the Lower Cretaceous Nanushuk Group. Low-relief anticlines possibly related to differential compaction and stratigraphic terminations of homoclinally-dipping sandstones form the primary trap types. This play is modeled as predominately charged by the Hanna trough play charging system (described in Chukchi shelf play 1), although some contribution from the gas-rich Colville basin play charging system (described in Chukchi shelf play

OIL AND GAS ENDOWMENTS OF BEAUFORT SHELF PLAYS
Risked, Undiscovered, Conventionally Recoverable Oil and Gas

PLAY NO.	PLAY NAME (UAI * CODE)	OIL (BBO)			GAS (TCFG)		
		F95	MEAN	F05	F95	MEAN	F05
0101	Undeformed Pre-Miss. Bsmt (UABS0101)	0.000	0.006	0.027	0.000	0.028	0.109
0200	Pre-Devonian (UABS0200)	0.000	0.173	0.505	0.000	3.534	9.958
0401	Endicott w/o Portion Shared/Chukchi (UABS0401)	0.000	0.037	0.120	0.000	0.109	0.303
0501	Lisburne Play (Beaufort Only: UABS0501)	0.006	0.208	0.805	0.009	0.452	2.117
0601	Upper Ellesmerian (Beaufort Only: UABS0601)	0.135	0.763	2.200	0.273	1.834	8.057
0701	Rift (Beaufort Only: UABS0701)	0.564	0.910	1.570	1.302	2.559	5.512
0800	Brookian Faulted Western Topset (UABS0800)	0.000	0.082	0.254	0.000	1.570	5.372
0902	Brookian Unstructured Western Topset (UABS0902)	0.000	0.146	0.631	0.000	0.211	0.748
1000	Brookian Faulted Western Turbidites (UABS1000)	0.000	0.029	0.095	0.000	0.601	1.923
1102	Brookian Unstructured Western Turbidite (UABS1102)	0.000	0.057	0.214	0.000	0.133	0.468
1201	Brookian Faulted Eastern Topset (UABS1201)	0.518	1.046	2.042	7.323	16.074	35.665
1302	Brookian Unstructured Eastern Topset (UABS1302)	0.907	1.648	3.497	0.539	0.813	1.258
1400	Brookian Faulted Eastern Turbidites (UABS1400)	0.000	0.183	0.355	0.000	3.585	7.252
1502	Brookian Unstructured Eastern Turbidites (UABS1502)	0.000	0.042	0.169	0.000	0.090	0.349
1602	Brookian Foldbelt (UABS1602)	1.205	2.038	3.680	1.662	3.188	6.108
1800	Endicott-Overlaps Chukchi (UABS1800)	0.000	0.0006	0.002	0.000	0.012	0.034
1900	Lisburne-Overlaps Chukchi (UABS1900)	0.000	0.018	0.083	0.000	0.065	0.273
2000	Ellesmerian Deep Gas-Overlaps Chukchi (UABS2000)	0.000	0.004	0.014	0.000	0.150	0.583
2100	Upper Ellesmerian-Overlaps Chukchi (UABS2100)	0.000	0.497	1.407	0.000	1.391	4.075
2200	Rift-Overlaps Chukchi (UABS2200)	0.248	0.606	1.300	0.855	2.166	4.404
2300	Sand Apron-Overlaps Chukchi (UABS2300)	0.000	0.291	1.173	0.000	4.895	17.000
2400	Turbidites (Torok)-Overlaps Chukchi (UABS2400)	0.000	0.003	0.021	0.000	0.008	0.057
2500	Topset (Nanushuk)-Overlaps Chukchi (UABS2500)	0.000	0.044	0.167	0.000	0.034	0.127
	FASPAG AGGREGATION	6.278	8.835	11.965	20.101	43.502	79.148

* *Unique Assessment Identifier, code unique to play.*

11) is possible. The play was tested at Diamond and Burger wells. A gas-charged sandstone 36 feet thick was encountered at Burger well, which is located within several miles of the easternmost fault of a fault system that passes downward into the Burger gas pool. This fault may have formed a migration conduit for gas escaping upward from Kuparuk sandstones within the

underlying Burger gas pool.

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