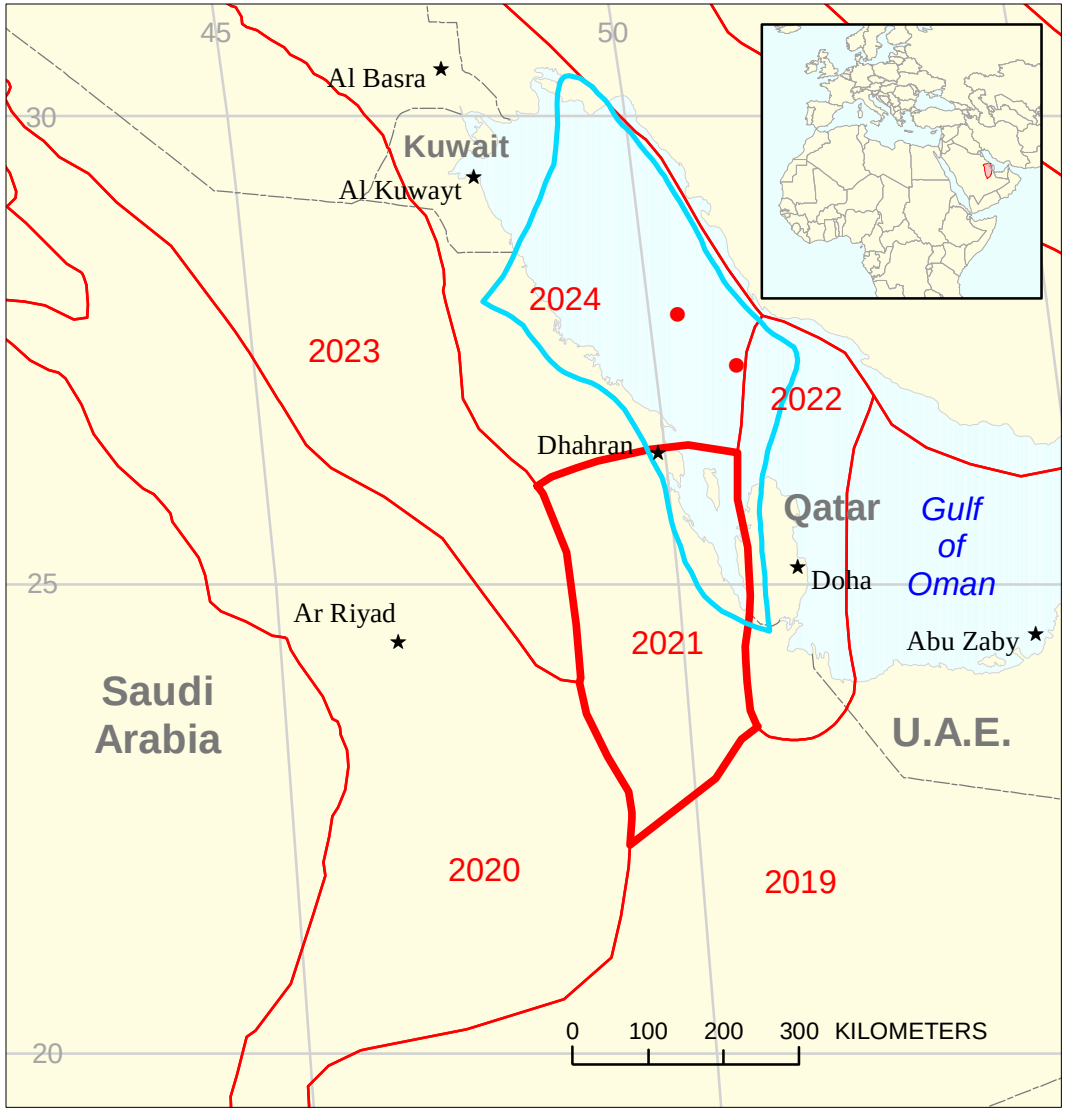
Go to Table of Contents

Go to index map

North Gulf Salt Basin Structural Gas Assessment Unit 20210102



North Gulf Salt Basin Structural Gas Assessment Unit 20210102

Greater Ghawar Uplift Geologic Province 2021

Other geologic province boundary

Geologic Summary

Detailed map of this assessment unit

Assessment Input Data

Assessment Results

- Assessment Unit Summary
- Detailed Assessment Results
- Undiscovered Field-Size Distributions

USGS PROVINCE: Greater Ghawar Uplift (2021)–Petroleum system is centered at Greater Ghawar but extends over parts of provinces 2019-Rub 'al Khali Basin; 2020-Interior Homocline-Central Arch; 2022-Qatar Arch; 2023-Widyan Basin-Interior Platform; 2024-Mesopotamian Foredeep

GEOLOGIST: R.M. Pollastro

TOTAL PETROLEUM SYSTEM: Central Arabia Qusaiba Paleozoic (202101)

ASSESSMENT UNIT: North Gulf Salt Basin Structural Gas (20210102)

DESCRIPTION: Assessment unit is defined by onshore and offshore portions of the Northern Arabian-Persian Gulf Salt Basin, east-central Arabian Peninsula, most of which is in province 2024 (Mesopotamian Foredeep) and some extending into provinces 2021 and 2022. Geographically defined by the extent of the underlying Hormuz Salt, the assessment unit is structurally bounded to the east by the Qatar Arch, to the north-northeast by the Zagros Fold Belt, and limited to the north-northwest by the extent of the source-rock facies. The assessment unit has a primary north-south structural grain due to basement fault blocks; structures are mainly domes over salt diapirs and salt-assisted or salt-enhanced horst-block anticlines.

SOURCE ROCKS: Primary source rock is the "basal hot shale" in the lower part of the Qusaiba Member, Lower Silurian Qalibah Formation. The basal hot shale is 3 to 75 m thick and occurs throughout most of the Central Arabian, Rub 'al Khali, and Gulf Salt Basins.

MATURATION: The basal hot shale is in the main gas generation window throughout most of the assessment unit. However, some isolated areas in the center of the Arabian Basin are overmature (Ro >2.6). Some fields produce sour gas from Permian Khuff carbonates.

MIGRATION: Migration is mainly vertical into Paleozoic reservoirs. Vertical migration into younger reservoirs (for example, G-Structure field of Iran produces Paleozoic gas from Jurassic (?) reservoirs) due to breaching of seals along Zagros has likely occurred.

RESERVOIR ROCKS: Reservoirs in two offshore gas fields and in Damman and Abu Sa'fah fields are in cyclic dolomitic shelf carbonates of the Late Permian Khuff Formation. Extent of reservoir facies in the Khuff is controlled mainly by anhydrite content. Production in discovered fields may also include Paleozoic clastic reservoirs.

TRAPS AND SEALS: Traps are structural and include domes over salt diapirs, and salt-assisted or enhanced horst-block anticlines (crest and flank) formed from draping of sediments over basement horst blocks having subsequent basement or halokinetic movement. Seals in known fields are mainly intraformational (shales, tight carbonates, and anhydrite) within the Khuff Formation. Thick evaporates, basal shale and carbonate of the Khuff Formation also provide a regional seal for potential undiscovered gas fields.

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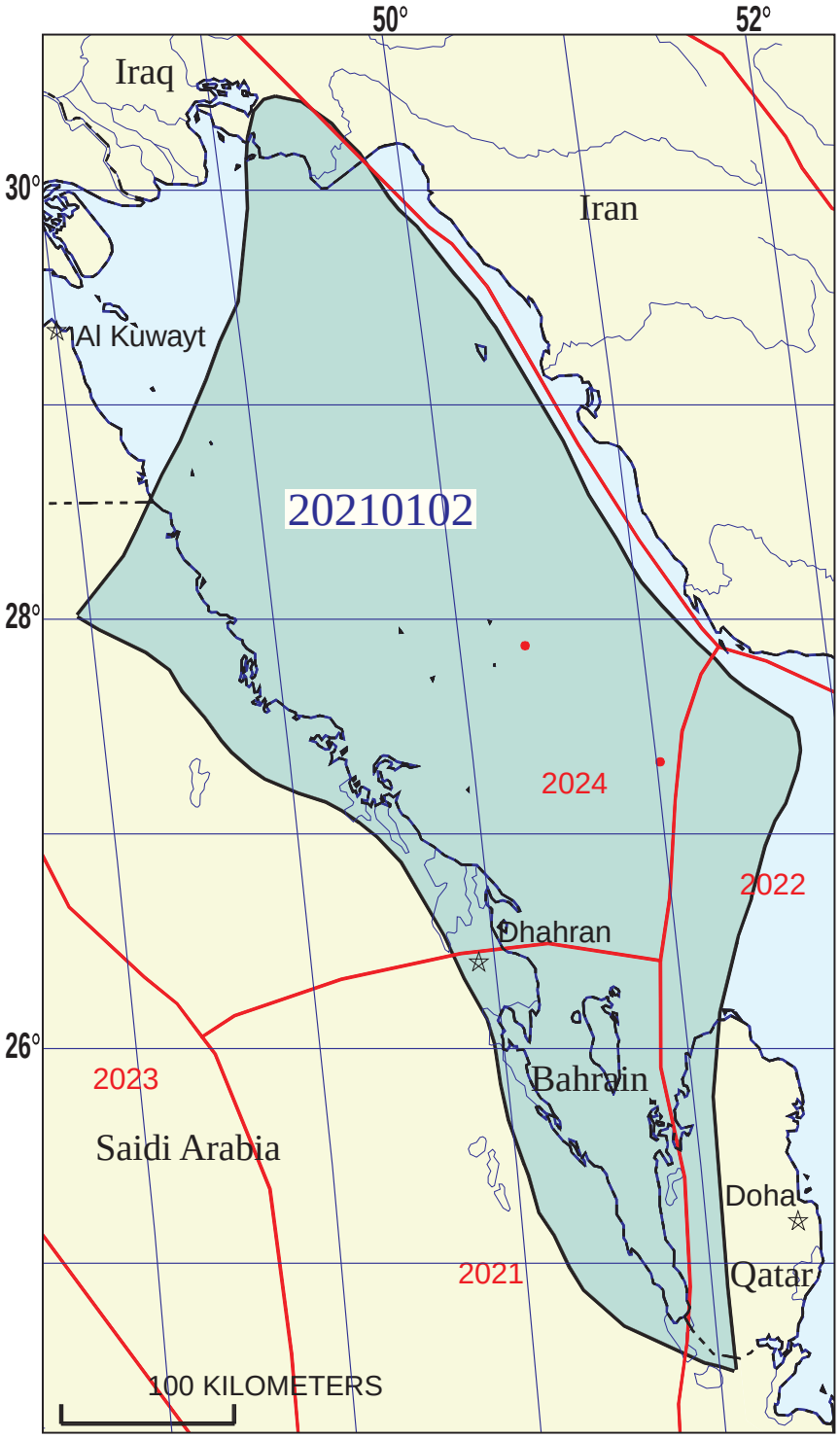

North Gulf Salt Basin Structural Gas Assessment Unit - 20210102

EXPLANATION

- Hydrography
- Shoreline
- 2021 — Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 20210102 — Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

SEVENTH APPROXIMATION
NEW MILLENNIUM WORLD PETROLEUM ASSESSMENT
DATA FORM FOR CONVENTIONAL ASSESSMENT UNITS

Date:……..	5/12/99		
Assessment Geologist:……..	R.M. Pollastro		
Region:……..	Middle East and North Africa	Number:	2
Province:……..	Greater Ghawar Uplift	Number:	2021
Priority or Boutique……..	Priority		
Total Petroleum System:……	Central Arabia Qusaiba Paleozoic	Number:	202101
Assessment Unit:……..	North Gulf Salt Basin Structural Gas	Number:	20210102
* Notes from Assessor	Lower 48 growth factor; assessment unit involves 3 priority provinces.		
	All fields discovered in 1966.		

CHARACTERISTICS OF ASSESSMENT UNIT

Oil (<20,000 cfg/bo overall) **or** Gas (≥20,000 cfg/bo overall):… Gas

What is the minimum field size?……. 20 mmboe grown (≥1mmboe)
(the smallest field that has potential to be added to reserves in the next 30 years)

Number of discovered fields exceeding minimum size:…… Oil: 0 Gas: 2

Established (>13 fields) _____ Frontier (1-13 fields) X Hypothetical (no fields) _____

Median size (grown) of discovered oil fields (mmboe):
1st 3rd _____ 2nd 3rd _____ 3rd 3rd _____

Median size (grown) of discovered gas fields (bcfg):
1st 3rd 17000 2nd 3rd _____ 3rd 3rd _____

Assessment-Unit Probabilities:

Attribute	Probability of occurrence (0-1.0)
1. **CHARGE:** Adequate petroleum charge for an undiscovered field ≥ minimum size……	1.0
2. **ROCKS:** Adequate reservoirs, traps, and seals for an undiscovered field ≥ minimum size……	1.0
3. **TIMING OF GEOLOGIC EVENTS:** Favorable timing for an undiscovered field ≥ minimum size	1.0

Assessment-Unit GEOLOGIC Probability (Product of 1, 2, and 3):…….. 1.0

4. **ACCESSIBILITY:** Adequate location to allow exploration for an undiscovered field ≥ minimum size…… 1.0

UNDISCOVERED FIELDS

Number of Undiscovered Fields: How many undiscovered fields exist that are ≥ minimum size?:
(uncertainty of fixed but unknown values)

Oil fields:……min. no. (>0)	_____	median no.	_____	max no.	_____
Gas fields:……min. no. (>0)	20	median no.	75	max no.	150

Size of Undiscovered Fields: What are the anticipated sizes (**grown**) of the above fields?:
(variations in the sizes of undiscovered fields)

Oil in oil fields (mmbo)……	min. size	_____	median size	_____	max. size	_____
Gas in gas fields (bcfg):……	min. size	120	median size	800	max. size	60000

Assessment Unit (name, no.)
North Gulf Salt Basin Structural Gas, 20210102

AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS

(uncertainty of fixed but unknown values)

Oil Fields:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……			
NGL/gas ratio (bngl/mmcfg)……			

Gas fields:	minimum	median	maximum
Liquids/gas ratio (bngl/mmcfg)……	22	44	66
Oil/gas ratio (bo/mmcfg)……			

SELECTED ANCILLARY DATA FOR UNDISCOVERED FIELDS

(variations in the properties of undiscovered fields)

Oil Fields:	minimum	median	maximum
API gravity (degrees)……			
Sulfur content of oil (%)……			
Drilling Depth (m) ……			
Depth (m) of water (if applicable)……			

Gas Fields:	minimum	median	maximum
Inert gas content (%)……			
CO_2 content (%)……			
Hydrogen-sulfide content (%)……			
Drilling Depth (m)……	1500	3000	6000
Depth (m) of water (if applicable)……	0	50	100

Assessment Unit (name, no.)
North Gulf Salt Basin Structural Gas, 20210102

ALLOCATION OF UNDISCOVERED RESOURCES IN THE ASSESSMENT UNIT TO COUNTRIES OR OTHER LAND PARCELS (uncertainty of fixed but unknown values)

1. Iran represents 40 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...			
Portion of volume % that is offshore (0-100%).....			

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		45	
Portion of volume % that is offshore (0-100%).....		100	

2. Saudi Arabia represents 30 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...			
Portion of volume % that is offshore (0-100%).....			

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		25	
Portion of volume % that is offshore (0-100%).....		90	

3. Bahrain represents 15 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...			
Portion of volume % that is offshore (0-100%).....			

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		10	
Portion of volume % that is offshore (0-100%).....		65	

4. Qatar represents 15 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...			
Portion of volume % that is offshore (0-100%).....			

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		20	
Portion of volume % that is offshore (0-100%).....		50	

5. Province 2021 represents 15 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…			
Portion of volume % that is offshore (0-100%)……			

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		25	
Portion of volume % that is offshore (0-100%)……		61	

6. Province 2022 represents 12 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…			
Portion of volume % that is offshore (0-100%)……			

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		25	
Portion of volume % that is offshore (0-100%)……		85	

7. Province 2024 represents 75 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…			
Portion of volume % that is offshore (0-100%)……			

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		50	
Portion of volume % that is offshore (0-100%)……		95	

North Gulf Salt Basin Structural Gas, AU 20210102
Undiscovered Field-Size Distribution