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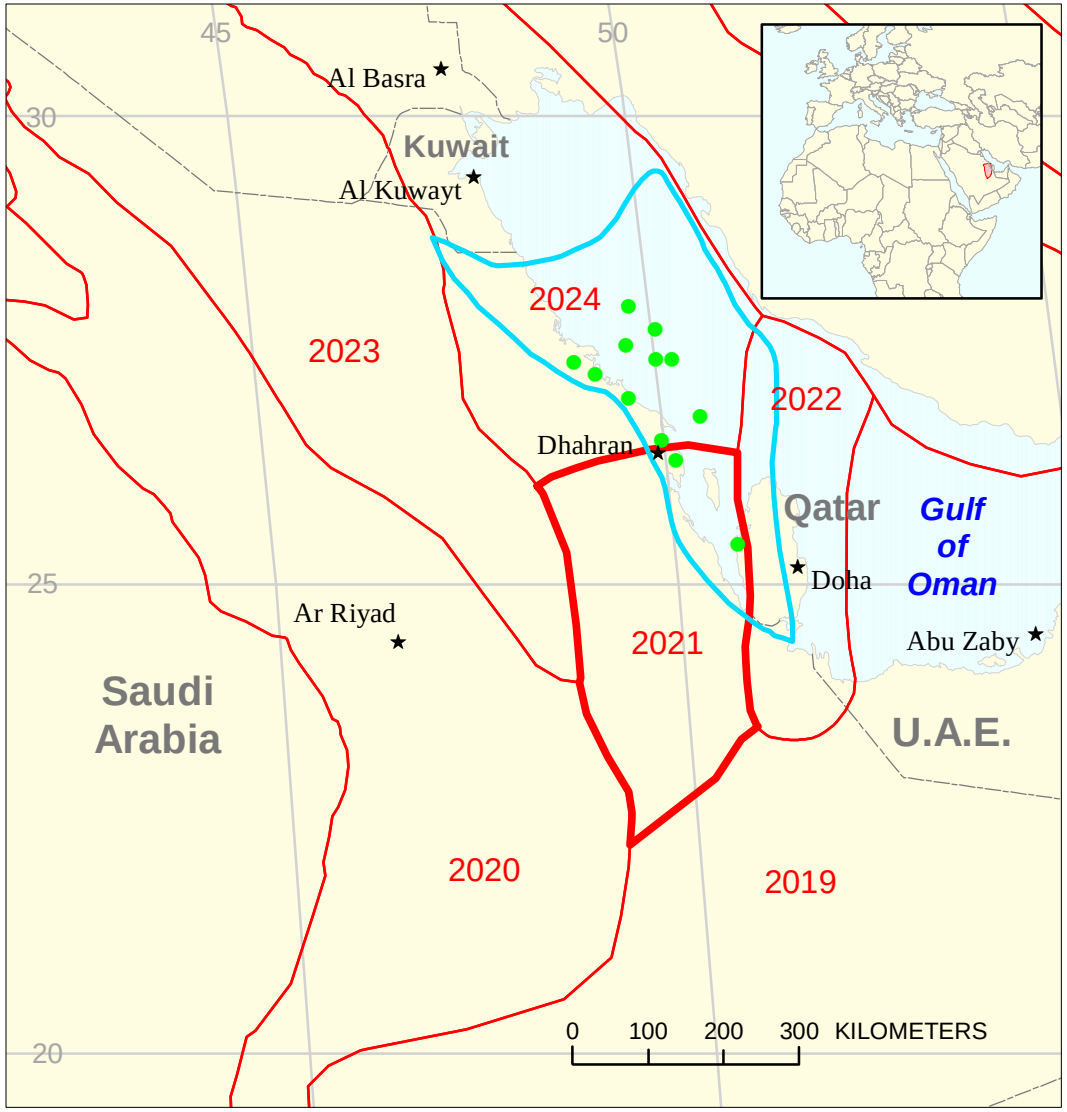
Salt-Involved Structural Oil Assessment Unit 20210202



Salt-Involved Structural Oil Assessment Unit 20210202
Greater Ghawar Uplift Geologic Province 2021
Other geologic province boundary

Geologic Summary

Detailed map of this assessment unit

Exploration/Discovery-History Data

- Plots of Known Field Sizes
- Plots of Grown Resources
- Tables

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 province 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: Arabian Sub-Basin Tuwaiq/Hanifa-Arab (202102)

ASSESSMENT UNIT: Salt-Involved Structural Oil (20210202)

DESCRIPTION: Assessment unit is defined by mostly offshore and some onshore portions as defined by the underlying salt of the Western Arabian-Persian Gulf Salt Basin, most of which is in province 2024 (Mesopotamian Foredeep) and some extending into the northeast corner of province 2021 and western half of 2022. Geographically defined mainly by the extent of the underlying Hormuz Salt and Tuwaiq/Hanifa source, the assessment unit is bounded to the east by the Qatar Arch, northeast by the Zagros Fold Belt, and to the north-northwest by the depositional extent of the source and reservoir facies, and the Jurassic Gotnia sub-basin. Two structural grains produce trending structures: (1) a north-south grain formed by basement fault blocks, and (2) northwest-southeast Najd rift trend. Halokinesis assisted the structural evolution of fields in this assessment unit and includes domes over salt diapirs and salt-assisted horst-block anticlines.

SOURCE ROCKS: The organic-rich, argillaceous limestone facies (as thick as 150 m) of the Middle Cretaceous Tuwaiq Mountain Formation is the primary source rock; however, the overlying Hanifa Formation is also a significant source. Oil-source correlations classify these oils into one Tuwaiq Mountain/Hanifa family. The Tuwaiq and Hanifa contain Type II organic matter; average TOC is about 3.5 and 2.5 weight percent, respectively. The evaporitic Gotnia Sub-basin to the north is a separate Jurassic system of different source-rock facies.

MATURATION: The Tuwaiq/Hanifa source in the assessment unit is mostly at mid-maturity and within main phase oil expulsion stage (Ro = 0.7 to 1.0 percent). A small northeast portion of the assessment unit (at Iran's G-Structure 1 gas field) along the Zagros is marginally mature in respect to oil generation.

MIGRATION: Migration is vertical from the Tuwaiq/Hanifa source into mainly Arab reservoirs. Source of gas found in Jurassic reservoirs in the assessment unit (G-Structure 1 field) is likely older Paleozoic (Silurian) sources where Paleozoic (mainly Khuff) seals have been breached.

RESERVOIR ROCKS: Primary reservoirs are the cyclic, shallow-water, carbonate grainstones and packstones of the Upper Jurassic Arab Formation (Arab A, B, C, D). Secondary reservoirs include the high microporous, fine-grained, fractured limestones of the Hanifa Formation, and Middle (Dhruma/Tuwaiq Formations) and Lower Jurassic (Marrat Formation) shelf carbonates.

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. The primary regional seal is the massive (150 m-thick) evaporites of the Upper Jurassic Hith Formation overlying the Arab Formation. Intraformational seals of the carbonate/anhydrite cycles of the Arab Formation (A, B, C, D) and shales and tight carbonates of the Hanifa, Dhruma, and Marrat Formations are important locally.

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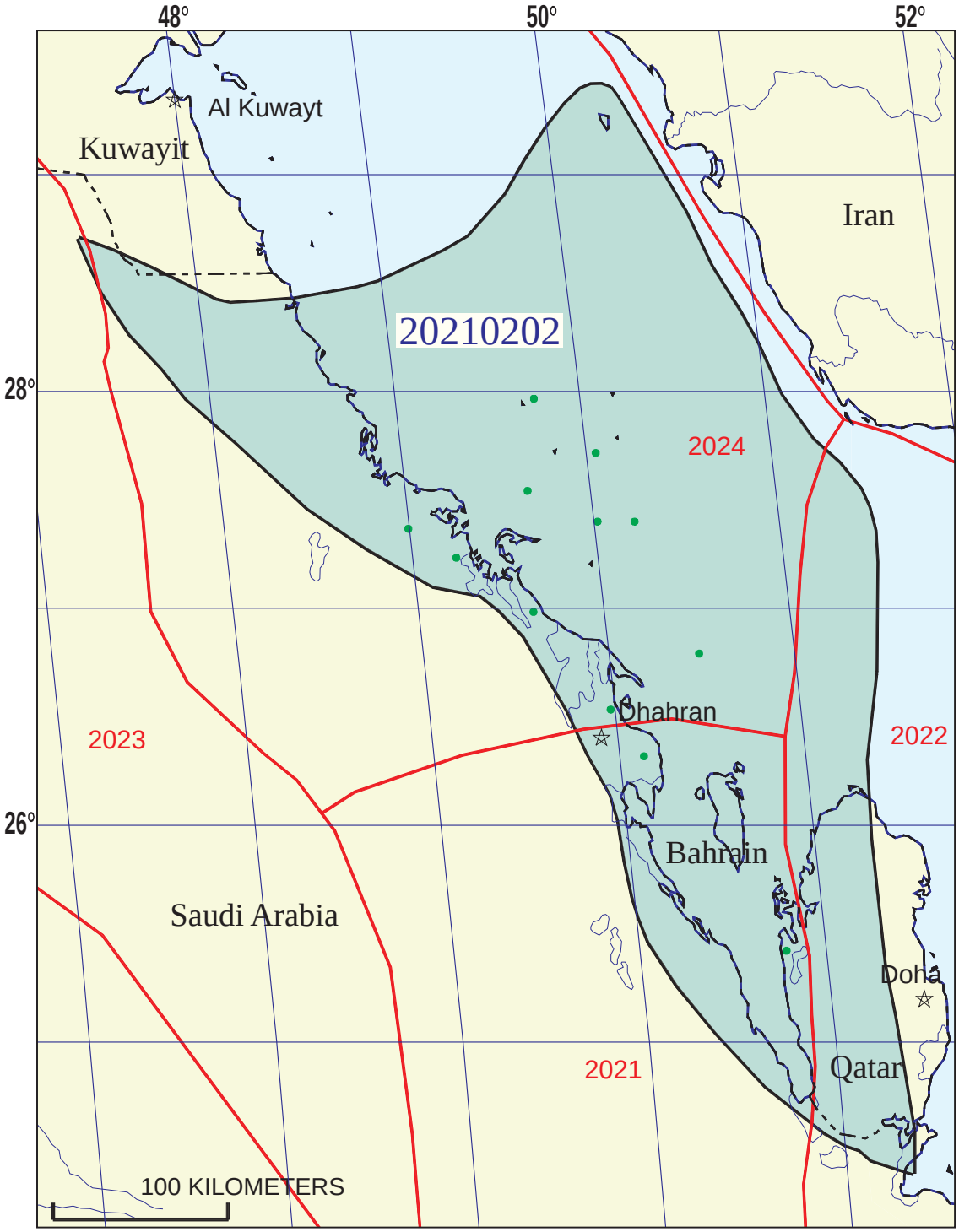

Salt-Involved Structural Oil Assessment Unit - 20210202

EXPLANATION

- Hydrography
- Shoreline
- 2021 — Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 20210202 — Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

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

Date:……..	5/14/99		
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:……	Arabian Sub-Basin Tuwaiq/Hanifa-Arab	Number:	202102
Assessment Unit:……..	Salt-Involved Structural Oil	Number:	20210202
* Notes from Assessor	Lower 48 growth factor. Assessment unit involves 3 priority provinces.		

CHARACTERISTICS OF ASSESSMENT UNIT

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

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: 12 Gas: 0

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

Median size (grown) of discovered oil fields (mmboe):
1st 3rd 5471 2nd 3rd 1008 3rd 3rd

Median size (grown) of discovered gas fields (bcfg):
1st 3rd 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)	10	median no.	50	max no.	100
Gas fields:……min. no. (>0)		median no.		max no.	

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	20	median size	150	max. size	6000
Gas in gas fields (bcfg):…… min. size		median size		max. size	

Assessment Unit (name, no.)
Salt-Involved Structural Oil, 20210202

AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS

(uncertainty of fixed but unknown values)

Oil Fields:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……	900	1200	1500
NGL/gas ratio (bngl/mmcfg)……	20	40	60

Gas fields:	minimum	median	maximum
Liquids/gas ratio (bngl/mmcfg)……			
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)……	14	30	42
Sulfur content of oil (%)……	1.2	2.5	6
Drilling Depth (m) ……	1000	2200	4000
Depth (m) of water (if applicable)……	0	50	100

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

Assessment Unit (name, no.)
Salt-Involved Structural Oil, 20210202

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

1. Iran represents 20 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		12	
Portion of volume % that is offshore (0-100%).....		100	

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

2. Saudi Arabia represents 50 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		68	
Portion of volume % that is offshore (0-100%).....		80	

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

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):...		1	
Portion of volume % that is offshore (0-100%).....		80	

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

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):...		19	
Portion of volume % that is offshore (0-100%).....		50	

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

5. Province 2021 represents 16 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		16	
Portion of volume % that is offshore (0-100%)……		60	

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

6. Province 2022 represents 16 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		16	
Portion of volume % that is offshore (0-100%)……		60	

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

7. Province 2024 represents 68 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		68	
Portion of volume % that is offshore (0-100%)……		85	

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

Salt Involved Structural Oil, AU 20210202
Undiscovered Field-Size Distribution