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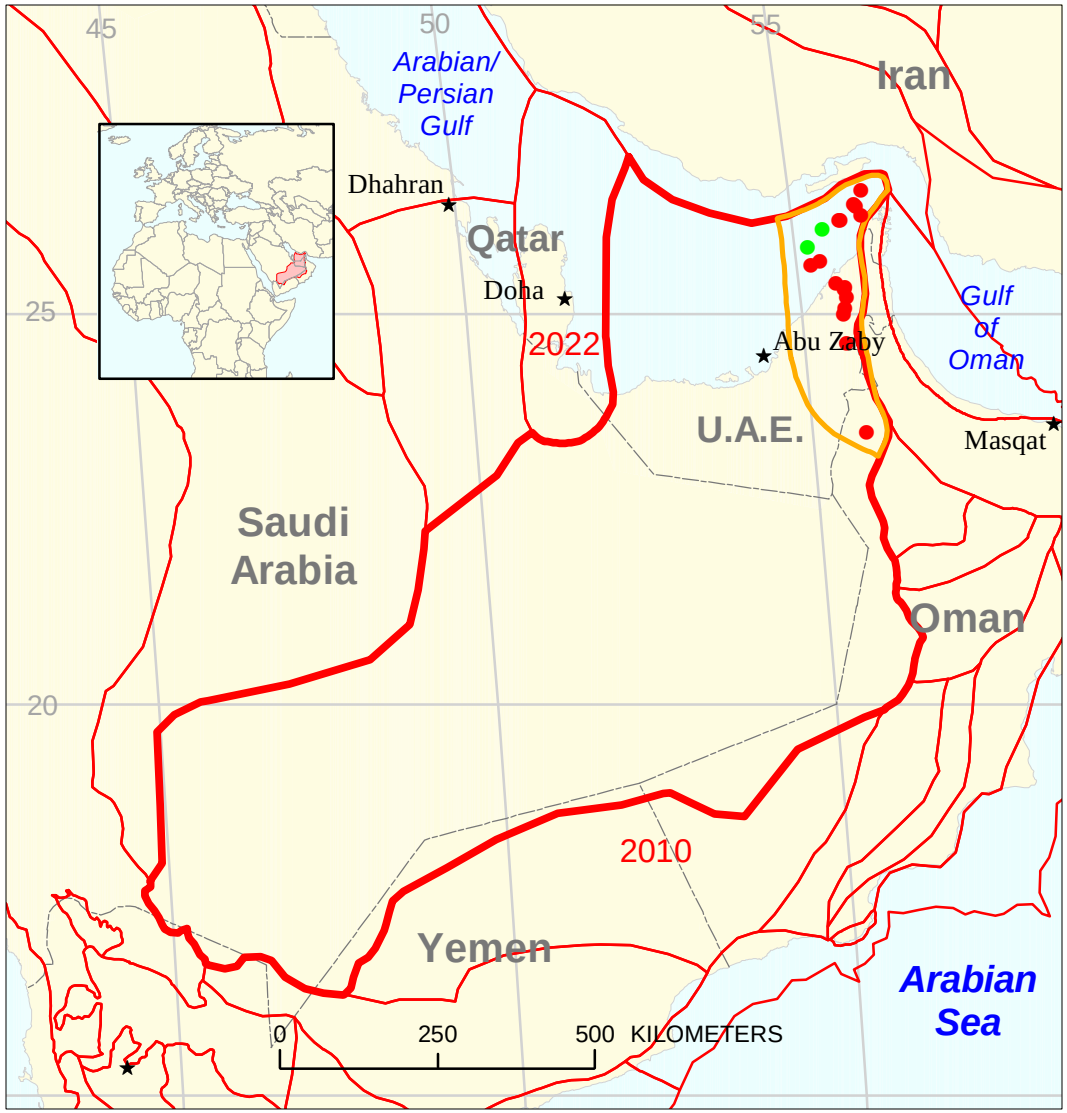
Mesozoic/Tertiary Foredeep Fold and Thrust Assessment Unit 20190103



Mesozoic/Tertiary Foredeep Fold and Thrust Assessment Unit 20190103

Rub Al Khali Basin Geologic Province 2019

Other petroleum system 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: Rub Al Khali Basin (2019)–Petroleum system is centered in the Rub 'al Khali Basin province but extends into the southeast corner of province 2022-Qatar Arch.

GEOLOGIST: R.M. Pollastro

TOTAL PETROLEUM SYSTEM: Cretaceous Thamama/Wasia (201901)

ASSESSMENT UNIT: Mesozoic/Tertiary Foredeep Fold and Thrust (20190103)

DESCRIPTION: This assessment unit is defined by the Omani foredeep and thrust front and Ras 'al Khaima sub-basin along the Oman Mountain and includes both offshore and onshore. Fields were formed during the Eocene and Miocene from tectonic loading of the Arabian platform and oceanic crust and mantle (ophiolites) thrust upon the Arabian plate with later secondary deformation. The assessment unit has a primary north-south structural grain formed by folding and thrust faults parallel to Oman thrust front. Mesozoic and Tertiary reservoirs are assessed separately recognizing possible overlap with Paleozoic.

SOURCE ROCKS: Four inferred source rocks are recognized in this assessment unit: (1) organic-rich, basinal facies of the Shu'aiba and possible, (2) Habshan Formation (3) a series of argillaceous dense layers (as thick as 500 ft net source) all of the Early Cretaceous Thamama Group, and (4) the Shilaif (Khatiyah) Formation basinal facies, Middle Cretaceous Wasia Group, may also extend into the foredeep. These source rocks contain Type II and I organic matter with about 1 to 10 percent TOC (1.3 to 2.0 percent average).

MATURATION: Thamama and Wasia source rocks are presently mature for gas generation along the deeper (> 4,000 m) portion of the foredeep and overthrust where temperatures have exceeded 170° and mature for oil along the western edge of the fold belt. Condensates are typically about 50° API and as high as 56°. Some mature (36 to 39° API) oils are produced from fields along the western fold belt. Gas was initially generated from the Shu'aiba source in the Oligocene (30 Ma) from the deepest portion of the foredeep. Most of the assessment unit is presently in the gas generation window.

MIGRATION: The Thamama has good carrier beds below the regional Nahr Umr Shale seal for lateral migration. Oil generated from the foredeep migrated updip and westerly out from the Omani foredeep into fields along the foldbelt. Later gas generation commencing in the Oligocene filled traps formed during 2nd Alpine compression in the Miocene by both lateral migration and vertical migration from thrust faults.

RESERVOIR ROCKS: Primary reservoirs are the cyclic, shallow-water, platform and shelf carbonate grainstones and packstones of the Lower Cretaceous Shu'aiba Formation and biocastic shoal buildups of the Middle Cretaceous Mishrif Formation. Minor reservoirs are in the Cretaceous Habshan and Lekhwair Formations with some vertical leakage into Tertiary Pabden and Gacharsan Formations.

TRAPS AND SEALS: Traps are structural and mainly (1) foredeep foldbelt anticlines due to Oman Mountain compression (2) fault-propagation folds, and 3) normal- and thrust-faulted anticlines. Some anticlines drape basement horst blocks and (or) are faulted due to Oman stress compression. Primary regional seals are the Nahr Umr, Laffan and Fiqa Shales.

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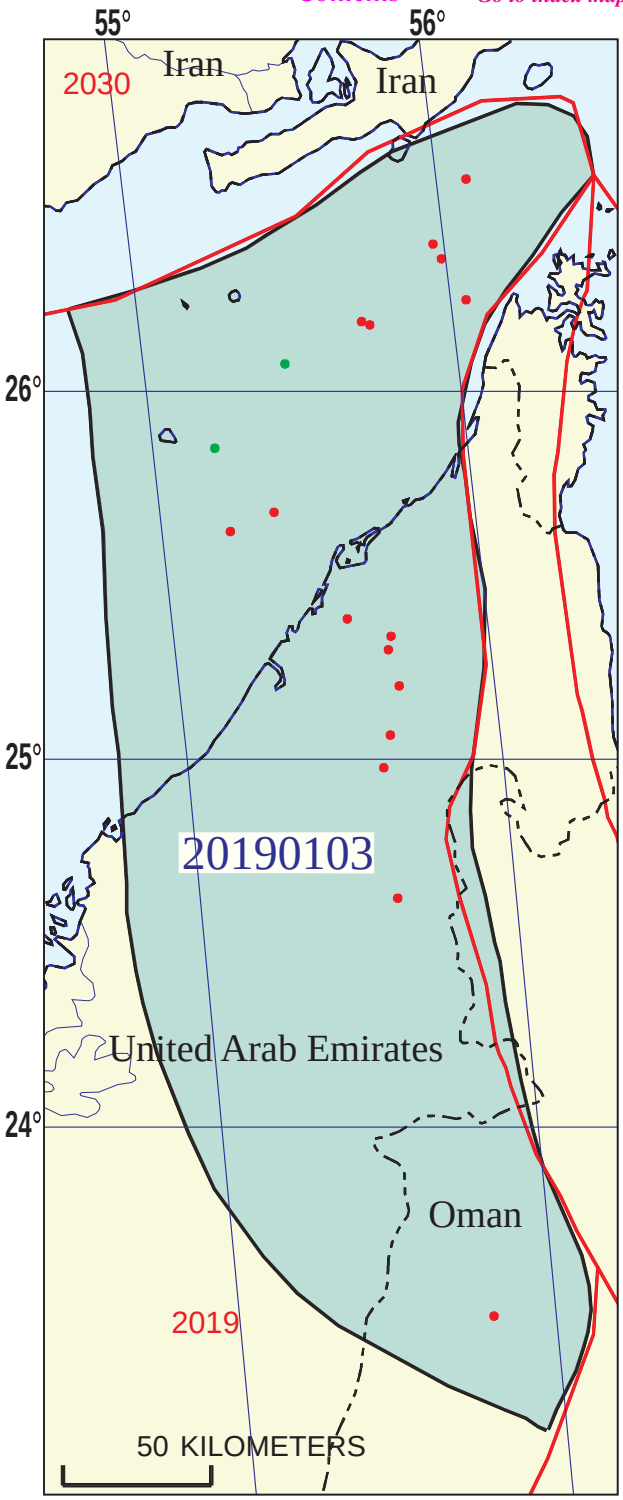


Mesozoic/Tertiary Foredeep Fold and Thrust Assessment Unit - 20190103

EXPLANATION

- Hydrography
- Shoreline
- 2019 Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 20190103 Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

USGS science for a changing world

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

Date:……..	12/8/99		
Assessment Geologist:……..	R.M. Pollastro		
Region:……..	Middle East and North Africa	Number:	2
Province:……..	Rub Al Khali Basin	Number:	2019
Priority or Boutique……	Priority		
Total Petroleum System:……	Cretaceous Thamama/Wasia	Number:	201901
Assessment Unit:……..	Mesozoic/Tertiary Foredeep Fold and Thrust	Number:	20190103
* Notes from Assessor	Lower 48-all growth function. This is an assessment of Mesozoic and Tertiary reservoirs (assessed separately from other reservoirs), recognizing possible overlap of Paleozoic.		

CHARACTERISTICS OF ASSESSMENT UNIT

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

What is the minimum field size?……. 10 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: 2 Gas: 14
Established (>13 fields) X Frontier (1-13 fields) _____ Hypothetical (no fields) _____

Median size (grown) of discovered oil fields (mmboe):
1st 3rd 139 2nd 3rd 86 3rd 3rd _____
Median size (grown) of discovered gas fields (bcfg):
1st 3rd 527 2nd 3rd 2260 3rd 3rd 942

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)	1	median no.	9	max no.	23
Gas fields:……min. no. (>0)	2	median no.	30	max no.	80

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	10	median size	30	max. size	1000
Gas in gas fields (bcfg):……min. size	60	median size	180	max. size	10000

Assessment Unit (name, no.)
Mesozoic/Tertiary Foredeep Fold and Thrust, 20190103

AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS

(uncertainty of fixed but unknown values)

Oil Fields:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……	3000	6000	9000
NGL/gas ratio (bngl/mmcfg)……	30	60	90

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)……	28	39	50
Sulfur content of oil (%)……	0.5	0.9	1.5
Drilling Depth (m) ……	1000	4000	5000
Depth (m) of water (if applicable)……	0	75	125

Gas Fields:	minimum	median	maximum
Inert gas content (%)……			
CO_2 content (%)……	0.1	4.6	14
Hydrogen-sulfide content (%)……	0.1	2	5
Drilling Depth (m)……	1000	4000	5500
Depth (m) of water (if applicable)……	0	75	125

Assessment Unit (name, no.)
Mesozoic/Tertiary Foredeep Fold and Thrust, 20190103

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

1. United Arab Emirates represents 65 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		65	
Portion of volume % that is offshore (0-100%)……		30	

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		65	
Portion of volume % that is offshore (0-100%)……		30	

2. Iran represents 10 areal % of the total assessment unit

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

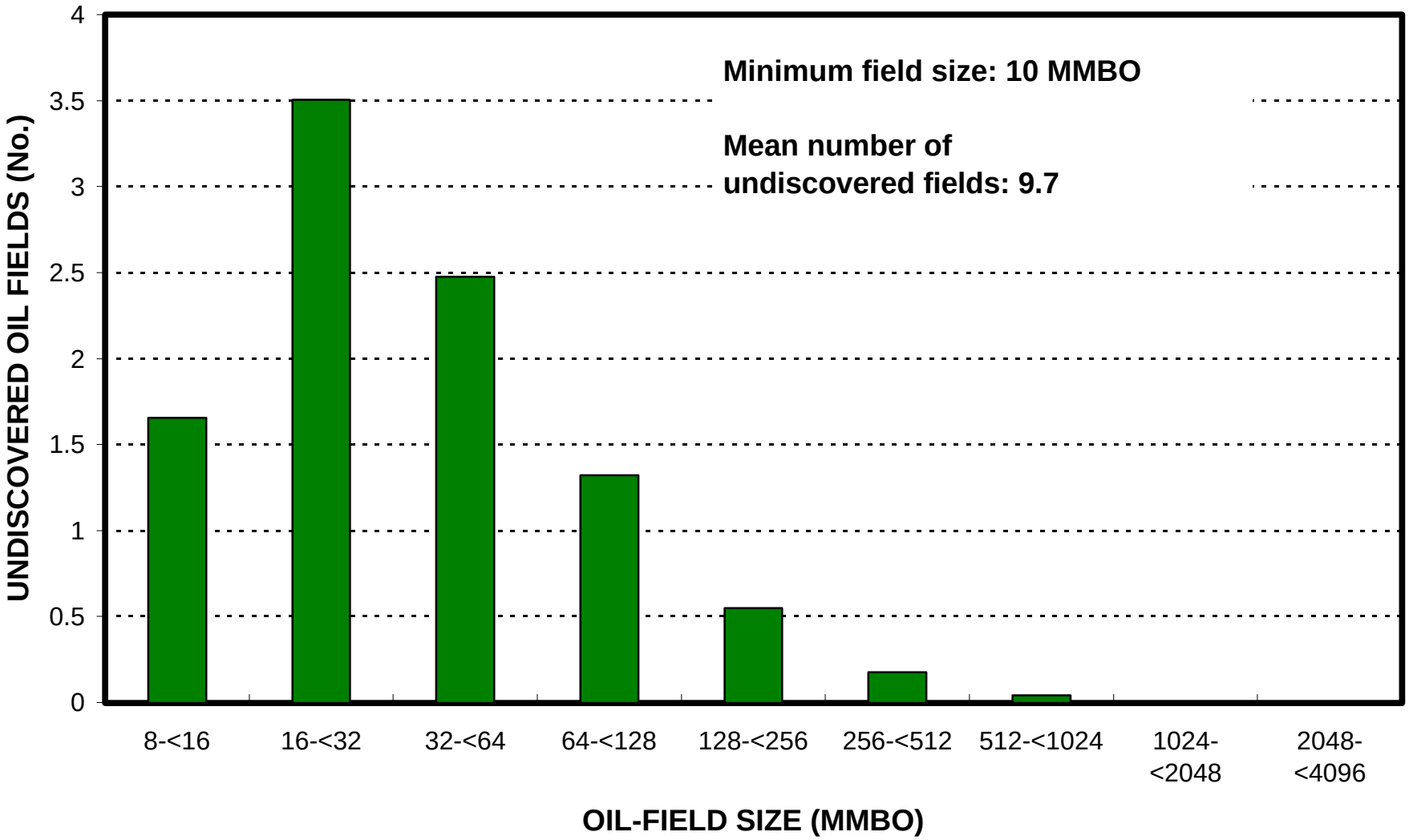
Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		10	
Portion of volume % that is offshore (0-100%)……		100	

3. Oman represents 25 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		25	
Portion of volume % that is offshore (0-100%)……		30	

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%)……		35	

Mesozoic/Tertiary Foredeep Fold and Thrust, AU 20190103
Undiscovered Field-Size Distribution



Mesozoic/Tertiary Foredeep Fold and Thrust, AU 20190103
Undiscovered Field-Size Distribution