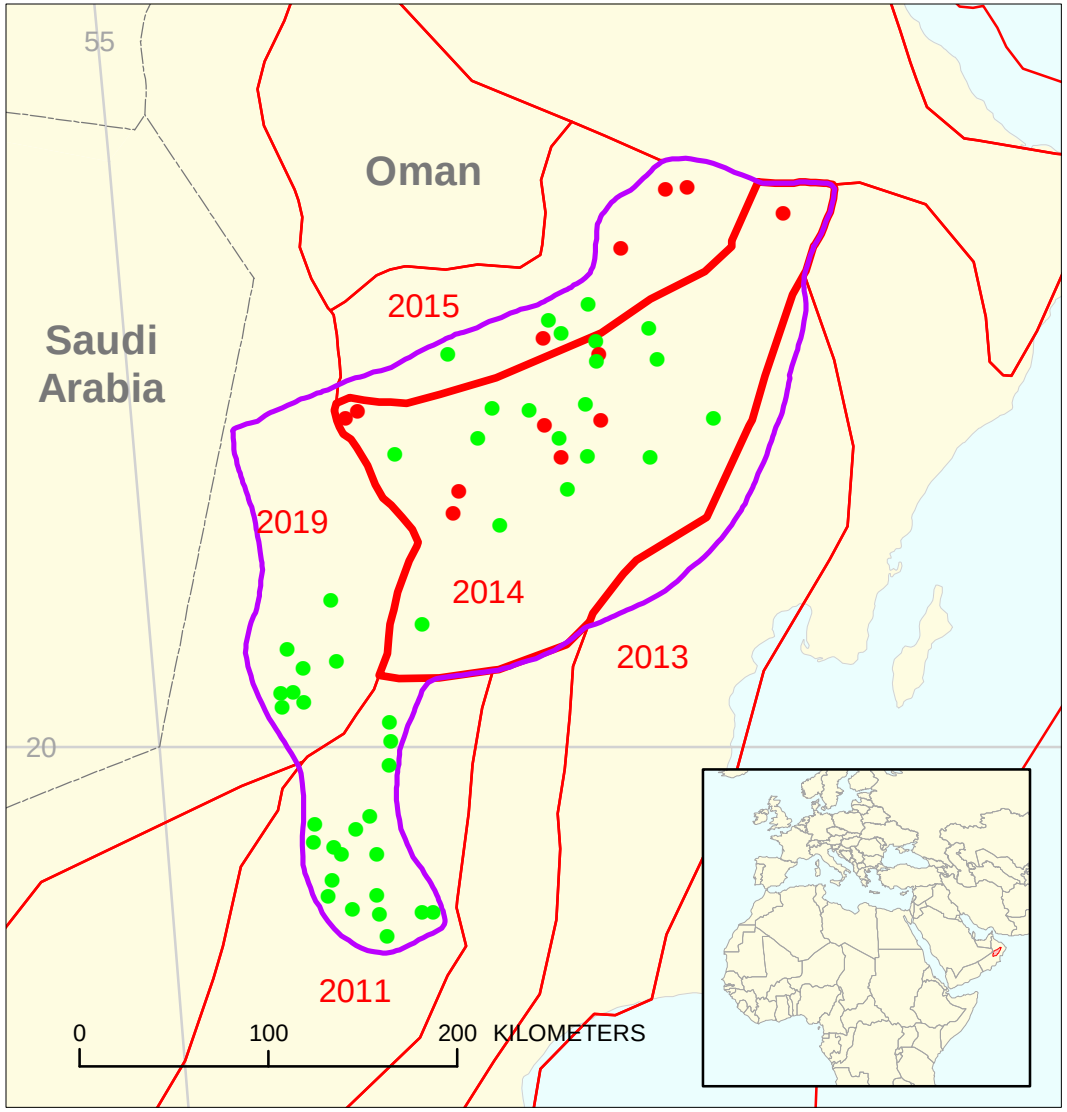
Go to Table of Contents

Go to index map

Ghaba-Makarem Combined Structural Assessment Unit 20140101



Ghaba-Makarem Combined Structural Assessment Unit 20140101
Ghaba Salt Basin Geologic Province 2014
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: Ghaba Salt Basin (2014)–Petroleum system is centered in the Ghaba Salt Basin but extends to the south over the Central Oman High and into the South Oman Salt Basin (2011). The petroleum system extends into the Rub 'al Khali province (2019) to the west, and the Huqf-Haushi uplift province (2013) to the east.

GEOLOGIST: R.M. Pollastro

TOTAL PETROLEUM SYSTEM: North Oman Huqf /'Q'-Haushi (201401)

ASSESSMENT UNIT: Ghaba-Makarem Combined Structural (20140101)

DESCRIPTION: This assessment unit lies entirely in Oman and defined by the underlying Cambrian Ara Salt and southern migration path of the Infracambrian 'Q-type' oils over the Central Oman High and into the South Oman Salt Basin province. Assessment unit is structurally bounded to the north by the the Makarem-Mabrouk high (an extension of the Central Oman Platform) and Oman Mountains, to the east-southeast by the Huqf-Haushi Uplift, to the south by the Central Oman High, and to the west by the Rub 'al Khali Basin. Fields of the Ghaba Salt Basin are structurally complex, salt-induced anticlines and domes.

SOURCE ROCKS: Source rocks are a multiple of carbonate and shale units in the Infracambrian Huqf Supergroup; most are associated with the Cambrian Ara Salt. In particular, oil-typing shows that more than 90 percent of the oil-in-place is derived from the Infracambiran 'Q' source rock unit near the top of the Ara Salt and in the Dhahaban source rock interval. These oils are light (~40° API gravity), mature, and low in sulfer. Huqf/'Q' source rocks contain structureless, Type I and Type II oil-prone organic matter. The Shuram Formation contains a thick (about 450 m), laterally extensive carbonate source unit in North Oman that averages about 2 weight percent TOC. North Oman Huqf-type oils correlate well with Huqf source rock extracts and have high sulfur (1.5 to 2.0 weight percent) content, with a distinctive geochemical signature of the so-called "X"-branched compounds.

MATURATION: Oil generation in Huqf/'Q' source rocks of the Ghaba Salt Basin occurred in two major stages: the first during the Middle Paleozoic (~450 Ma), and a second during the Triassic (~250 Ma). Early gas generation also occurred during the Middle Paleozoic with a peak gas phase during the Late Cretaceous/Early Tertiary.

MIGRATION: Migration is both vertical and lateral into multiple, often stacked, reservoirs ranging in age from Infracambrian to Cretaceous. Long-distance (150 km), migration of 'Q-type' oils occurred in a southward pathway along the regional Permian Khuff seal and into Gharif reservoirs far into the South Oman Salt Basin.

RESERVOIR ROCKS: Reservoirs include clastics and carbonates ranging in age from Infracambrian to Cretaceous. The main oil reservoirs are clastics of the Permian-Carboniferous Haushi Group (Gharif and Al-Khlata Formations); some production is from the overlying Permian Khuff Formation. Deep gas is produced mainly from Middle Cambrian to Lower

Ordovician clastics of the Haima Supergroup. Future gas reservoirs may include the Infracambrian Buah Limestone of the Huqf Supergroup.

TRAPS AND SEALS: Traps vary and are structurally complex, salt-induced anticlines and domes. Some structure have been broken up into several fault blocks by crestal collapse features. Highly faulted structures are often water bearing. Specific common trap styles are faulted closures, dip closures, and faulted-dip closures. Primary regional seals are: (1) the Cambrian-Ordovician Mabrouk shale; (2) the Permian Khuff Formation carbonates; and (3) thick shales of the Cretaceous Nahr Umr and Fiqa Formations. Multiple regional and intraformational seals also occur throughout the section. In the Haushi reservoirs, gas fields tend to have a thicker Khuff seal and lesser fault throw than the oil fields.

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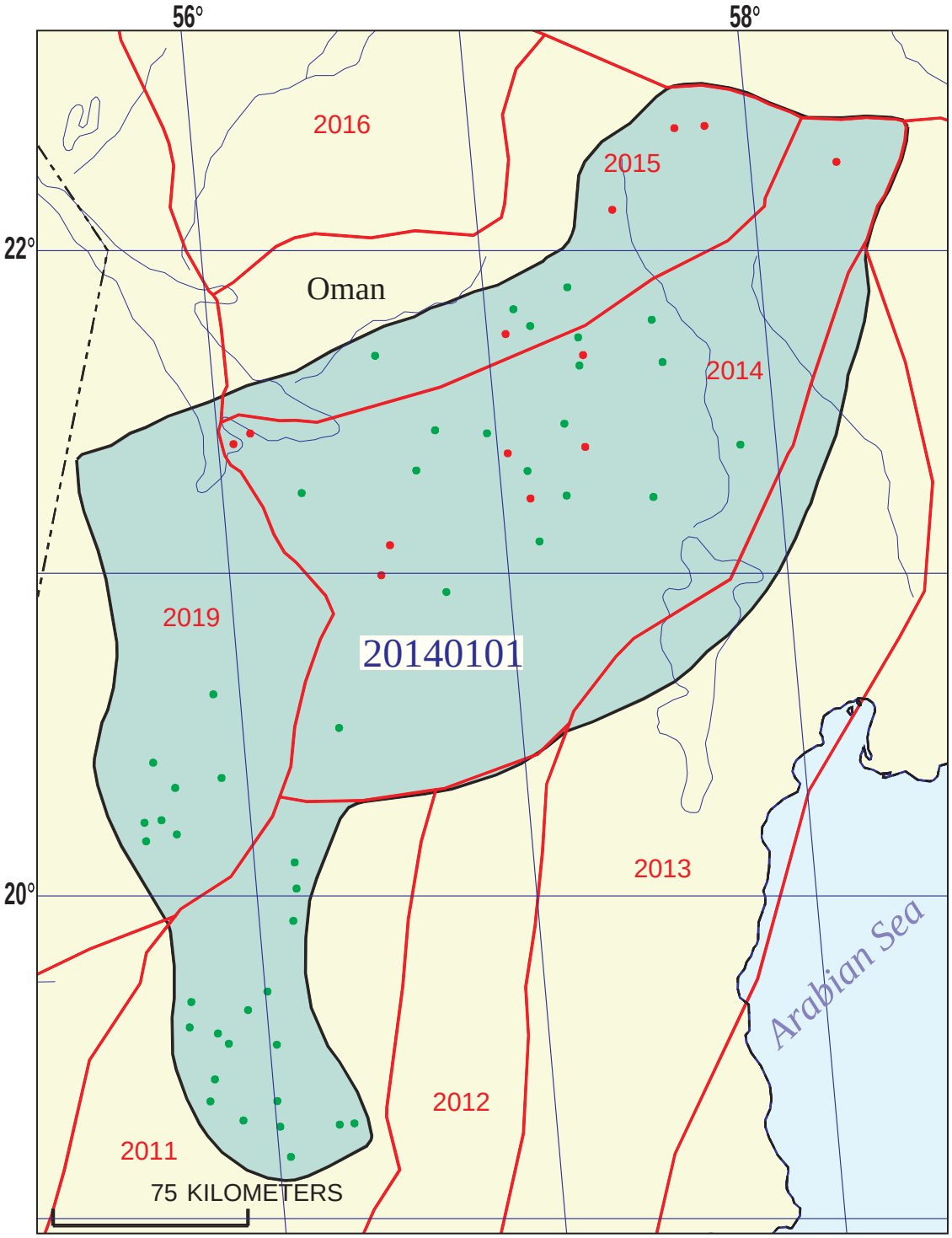


Ghaba-Makarem Combined Structural Assessment Unit - 20140101

EXPLANATION

- Hydrography
- Shoreline
- 2014 — Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 20140101 — Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

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

Date:……..	10/7/98		
Assessment Geologist:……..	R.M. Pollastro		
Region:……..	Middle East and North Africa	Number:	2
Province:……..	Ghaba Salt Basin	Number:	2014
Priority or Boutique……	Priority		
Total Petroleum System:……	North Oman Huqf/'Q'-Haushi	Number:	201401
Assessment Unit:……..	Ghaba-Makarem Combined Structural	Number:	20140101
* Notes from Assessor			

CHARACTERISTICS OF ASSESSMENT UNIT

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

What is the minimum field size?……. 5 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: 38 Gas: 10
Established (>13 fields) X Frontier (1-13 fields) _____ Hypothetical (no fields) _____

Median size (grown) of discovered oil fields (mmboe):
1st 3rd 76.8 2nd 3rd 34.8 3rd 3rd 15.1
Median size (grown) of discovered gas fields (bcfg):
1st 3rd 361 2nd 3rd 588 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)	5	median no.	40	max no.	100
Gas fields:……min. no. (>0)	2	median no.	20	max no.	40

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	5	median size	10	max. size	350
Gas in gas fields (bcfg):…… min. size	30	median size	200	max. size	8000

Assessment Unit (name, no.)
Ghaba-Makarem Combined Structural, 20140101

AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS

(uncertainty of fixed but unknown values)

Oil Fields:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……	2000	3000	4000
NGL/gas ratio (bngl/mmcfg)……	50	75	100

Gas fields:	minimum	median	maximum
Liquids/gas ratio (bngl/mmcfg)……	25	35	45
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)……	15	39	52
Sulfur content of oil (%)……	0.2	0.4	0.6
Drilling Depth (m) ……	2000	2500	3000
Depth (m) of water (if applicable)……			

Gas Fields:	minimum	median	maximum
Inert gas content (%)……			
CO_2 content (%)……			
Hydrogen-sulfide content (%)……			
Drilling Depth (m)……	3800	5000	6000
Depth (m) of water (if applicable)……			

Assessment Unit (name, no.)
Ghaba-Makarem Combined Structural, 20140101

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

1. Province 2014 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):...		50	
Portion of volume % that is offshore (0-100%).....		0	

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%).....		0	

2. Province 2015 represents 13 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		13	
Portion of volume % that is offshore (0-100%).....		0	

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		14	
Portion of volume % that is offshore (0-100%).....		0	

3. Province 2019 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):...		20	
Portion of volume % that is offshore (0-100%).....		0	

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%).....		0	

4. Province 2011 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):...		13	
Portion of volume % that is offshore (0-100%).....		0	

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

5. Province 2013 represents 5 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		4	
Portion of volume % that is offshore (0-100%).....		0	

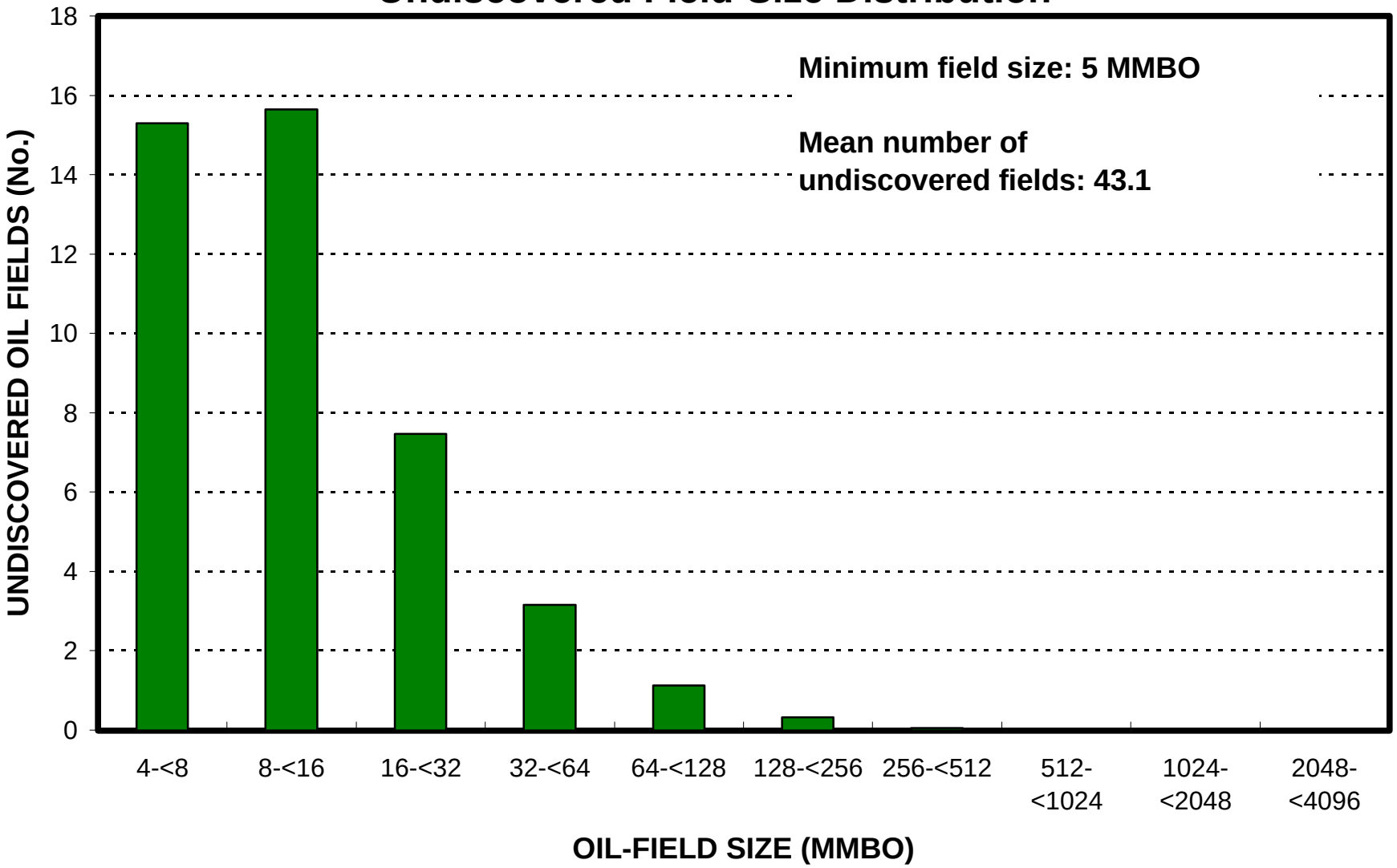
Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		4	
Portion of volume % that is offshore (0-100%).....		0	

6. Oman represents 100 areal % of the total assessment unit

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

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

Ghaba-Makarem Combined Structural, AU 20140101
Undiscovered Field-Size Distribution



Ghaba-Makarem Combined Structural, AU 20140101
Undiscovered Field-Size Distribution