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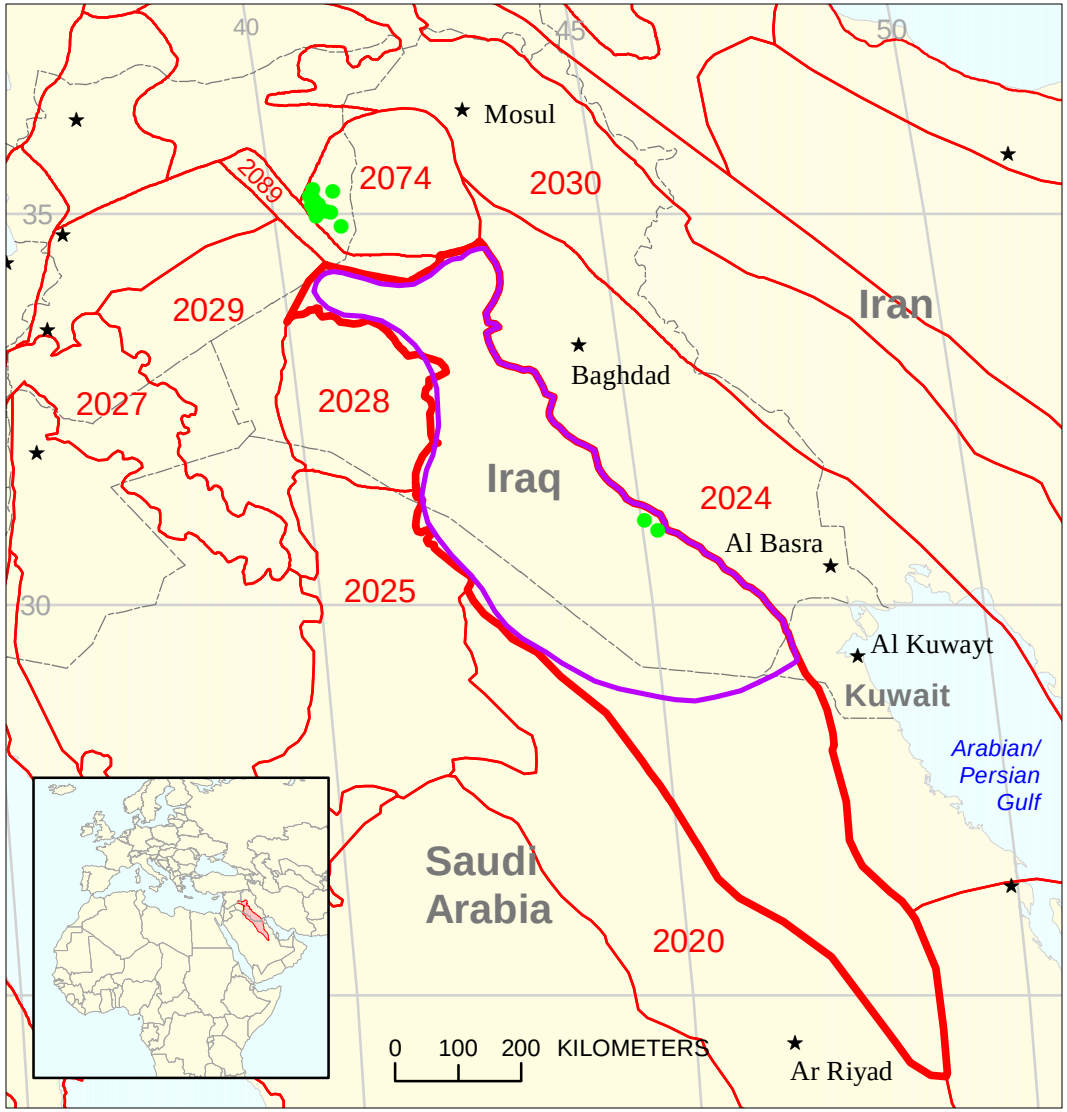
Platform Horst/Graben-Related Oil Assessment Unit 20230201



Platform Horst/Graben-Related Oil Assessment Unit 20230201

Widyan Basin-Interior Platform Geologic Province 2023

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: Widyan Basin-Interior Platform (2023) Saudi Arabia and Iraq

GEOLOGIST: J.E. Fox

TOTAL PETROLEUM SYSTEM: Jurassic Gotnia/Barsarin/Sargelu/Najmah (202302)

ASSESSMENT UNIT: Platform Horst/Graben-Related Oil (20230201)

DESCRIPTION: Oil occurs in faulted structural traps in Jurassic bar or shelf margin calcarenite lenses that formed around the Gotnia intrashelf basin. They are locally interbedded with lime mud source rocks, and in the deeper part of the basin to the east muddy lime predominates. Younger Jurassic seal rocks are distributed throughout the Total Petroleum System.

SOURCE ROCKS: Source of petroleum is cyclically bedded Callovian-Oxfordian-Kimmeridgian rocks that formed in three restricted intrashelf basins on the passive margin platform of the Tethys ocean following Permo-Triassic rifting. Large quantities of organic matter, mostly algal (amorphous alignite of Type II capable of generating large amounts of petroleum), accumulated under anoxic bottom conditions in the basin centers. In the Arabian and southern Arabian Gulf Basins, source rock formations are primarily the Hanifa (average TOC 2.6 percent) and Tuwaiq Mountain (2 to 5 percent TOC; 22.2 mg hydrocarbons/g rock) Formations. In the Gotnia Bbasin, source rocks are present in the Sargelu, Naokelekan, Gotnia, Barsarin, and Chi Gara Formations. The TOC averages are similar to the Tuwaiq Mountain. To the north, the tectonic instability of the Mosul Block has resulted in poor development of source rocks.

MATURATION: Maturation of the Upper Jurassic source-rock formations in the Gotnia Basin began around 90 Ma, with peak generation from 85 to 13 Ma. Because of slower rate of deposition in the Arabian Basin, the Hanifa did not begin generation of petroleum until about 55 Ma.

MIGRATION: Petroleum generated from Jurassic source rocks in the Gotnia and Arabian Basins moved updip into basement-related block faulted structures that have moved periodically since Precambrian. Basement faults and any associated fractures that have been periodically reactivated throughout Phanerozoic time are good conduits for fluid migration.

RESERVOIR ROCKS: The best reservoir properties are in cyclic Middle to Late Jurassic high-energy calcarenites and oolite facies marginal to the deeper intrashelf basins. A typical cycle in the Arab and Hanifa Formations in the Arabian Basin consists of a shallowing-upward marine carbonate sequence with ooidal-pelletoidal grainstone capped by anhydrite. The Namjah Limestone and Gotnia Formations in the Gotnia Basin have similar facies but are less cyclic.

TRAPS AND SEALS: Traps are on fault block anticlines, elongate in a general north-south direction, that occur over reactivated, deep-seated pre-Cambrian/Hercynian faults with some “drape” compaction. Projection of these structures from the western Widyan Basin northward to the Western Desert seems reasonable. Numerous prospects and structures have been identified in Iraq, many of

them with irregular forms. Anhydrites in the Hith and upper Gotnia Formations are regional seals. Local seals are tight anhydrite and dolomite in the Arab and Gotnia Formations.

REFERENCES:

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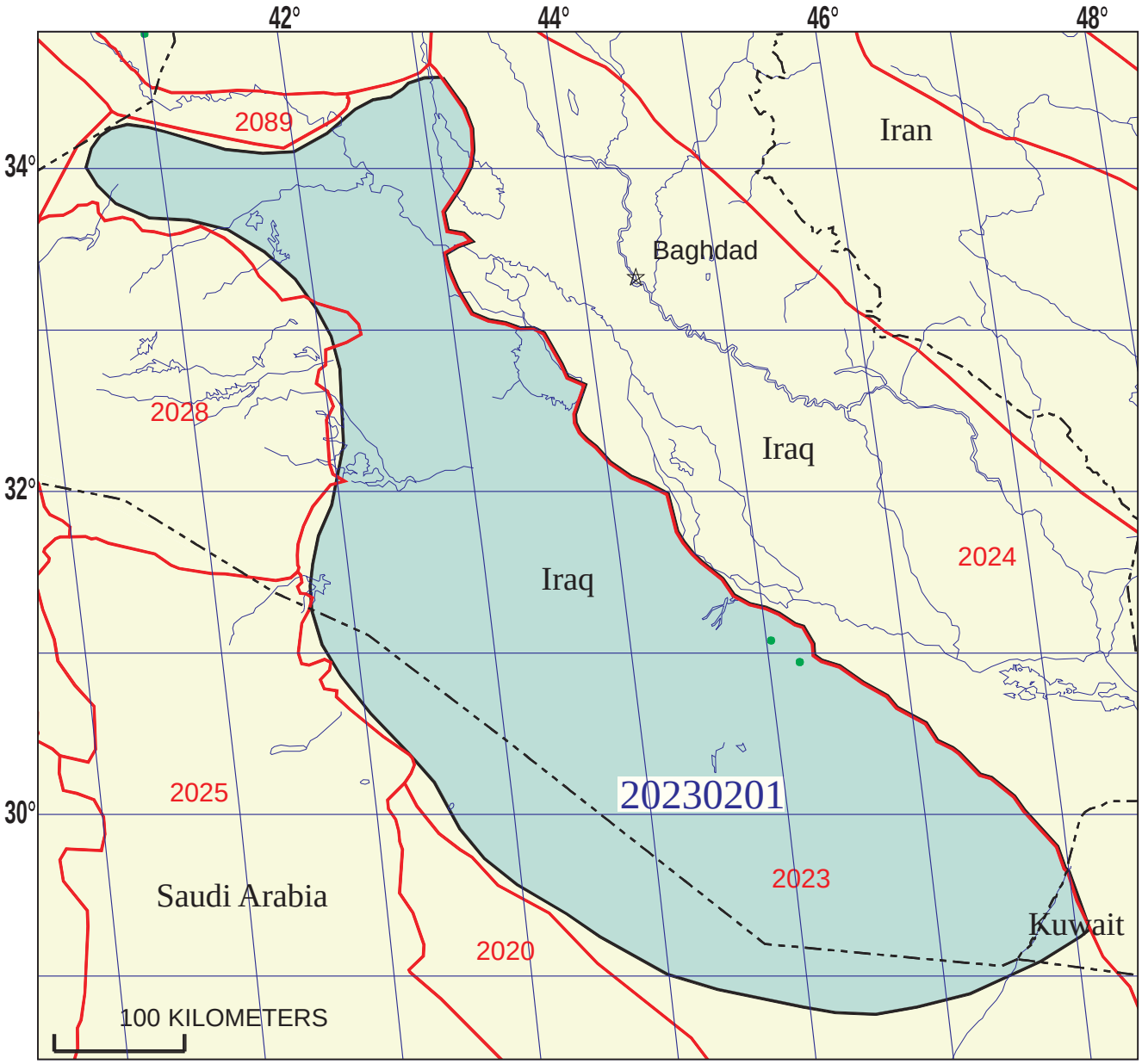
Cole, G.A., Carrigan, W.J., Colling, E.L., Halpern, H.I., Al-Khadhrawi, M.R., and Jones, P.J., 1994, The organic geochemistry of the Jurassic petroleum system in Eastern Saudi Arabia, *in* Embry, A.F., Beauchamp, B., and Glass, D.J., eds., Pangea—Global Environments and Resources: Canadian Society of Petroleum Geologists Memoir 17, p. 413-438.

Murris, R.J., 1986, Middle East stratigraphic evolution and oil habitat: American Association of Petroleum Geologists, v. 64, p. 597-618.

Sadooni, F.N., 1997, Stratigraphy and petroleum prospects of Upper Jurassic carbonates in Iraq: Petroleum Geoscience, v. 3, p. 233-243.



Platform Horst/Graben-Related Oil Assessment Unit - 20230201

EXPLANATION

- Hydrography
- Shoreline
- 2023 — Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 20230201 — Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

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

Date:……..	8/26/99		
Assessment Geologist:……..	T.S. Ahlbrandt		
Region:……..	Middle East and North Africa	Number:	2
Province:……..	Widyan Basin-Interior Platform	Number:	2023
Priority or Boutique……	Priority		
Total Petroleum System:……	Jurassic Gotnia/Barsarin/Sargelu/Najmah	Number:	202302
Assessment Unit:……	Platform Horst/Graben-Related Oil	Number:	20230201
* Notes from Assessor	Lower 48-all growth function.		

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: 13 Gas: 0
Established (>13 fields) _____ Frontier (1-13 fields) X Hypothetical (no fields) _____

Median size (grown) of discovered oil fields (mmboe):
1st 3rd 38 2nd 3rd 16 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)	5	median no.	100	max no.	200
Gas fields:……min. no. (>0)	1	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	5	median size	25	max. size	900
Gas in gas fields (bcfg):……min. size	30	median size	100	max. size	2000

Assessment Unit (name, no.)
Platform Horst/Graben-Related Oil, 20230201

AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS

(uncertainty of fixed but unknown values)

Oil Fields:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……	400	800	1200
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)……	20	32	40
Sulfur content of oil (%)……	0.5	2	4
Drilling Depth (m) ……	1000	2000	5000
Depth (m) of water (if applicable)……			

Gas Fields:	minimum	median	maximum
Inert gas content (%)……			
CO_2 content (%)……			
Hydrogen-sulfide content (%)……			
Drilling Depth (m)……	1000	2000	5000
Depth (m) of water (if applicable)……			

Assessment Unit (name, no.)
Platform Horst/Graben-Related Oil, 20230201

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

1. Saudi Arabia 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%)……		0	

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%)……		0	

2. Iraq represents 85 areal % of the total assessment unit

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

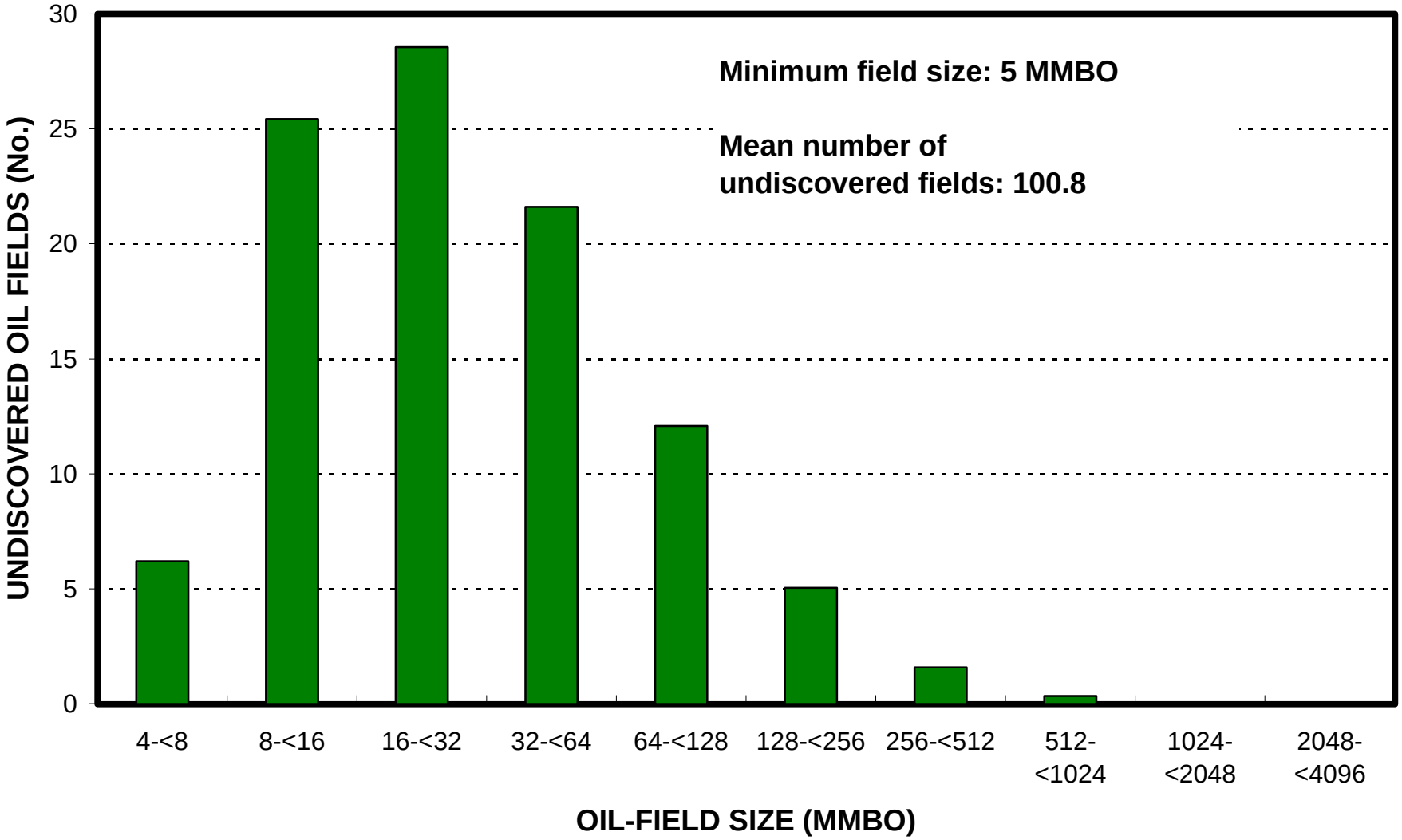
Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		90	
Portion of volume % that is offshore (0-100%)……		0	

3. Syria 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):…		5	
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):…		0	
Portion of volume % that is offshore (0-100%)……		0	

Platform Horst/Graben-Related Oil, AU 20230201
Undiscovered Field-Size Distribution



Platform Horst/Graben-Related Oil, AU 20230201
Undiscovered Field-Size Distribution