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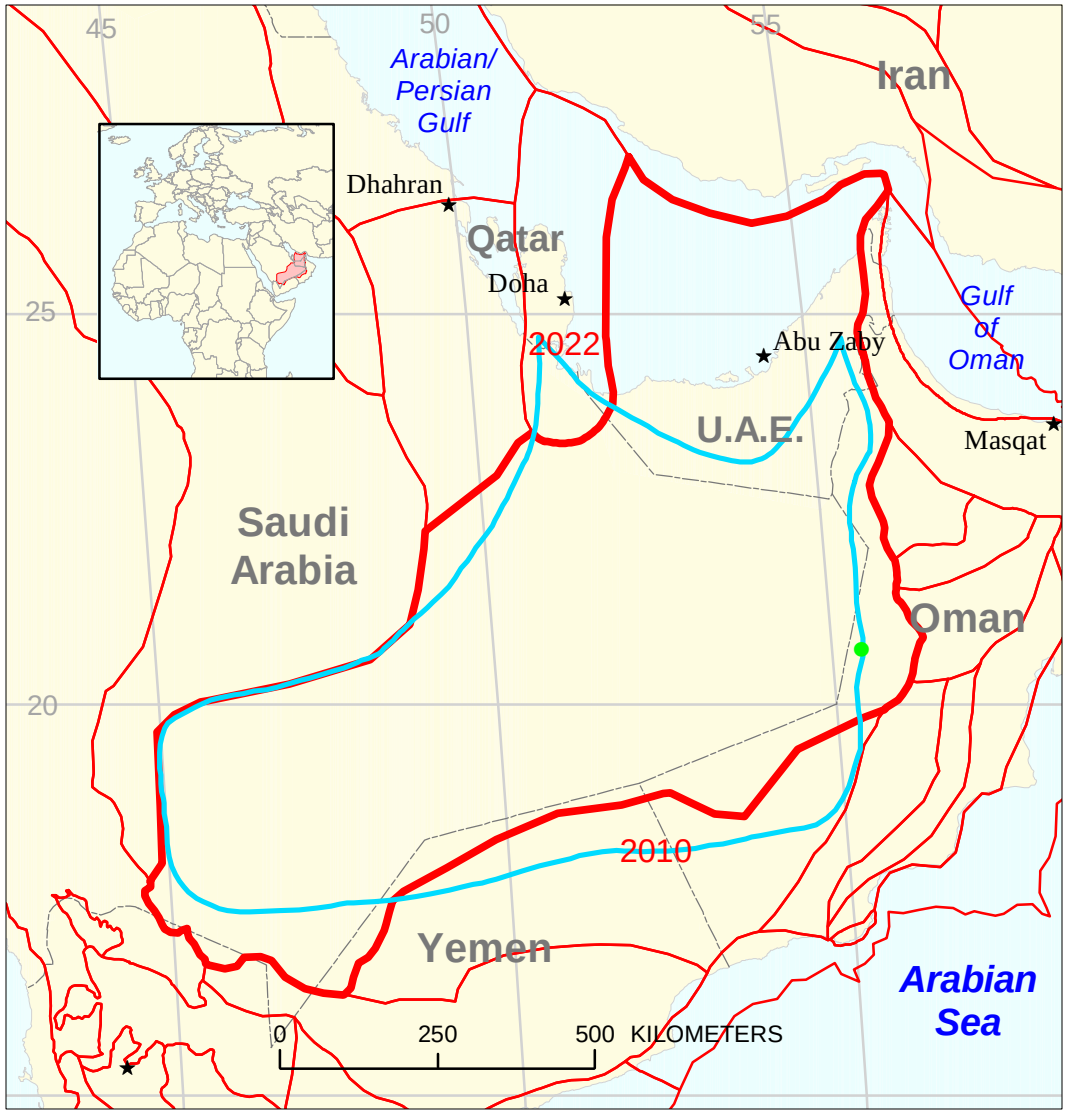
Paleozoic Reservoirs
Assessment Unit 20190302



Paleozoic Reservoirs Assessment Unit 20190302
Rub Al Khali Basin Geologic Province 2019
Other petroleum system 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: Rub Al Khali Basin (2019) **GEOLOGIST:** C.J. Schenk

TOTAL PETROLEUM SYSTEM: Silurian Qusaiba (201903)

ASSESSMENT UNIT: Paleozoic Reservoirs (20190302)

DESCRIPTION: This assessment unit encompasses most of the Rub al Khali Basin in Saudi Arabia, Oman, and Yemen where structures are related to extensive regional wrench fault systems and faults related to salt structures.

SOURCE ROCKS: Source rocks are hot shales of the basal Qusaiba Member of the Lower Silurian Qalibah Formation, which occurs throughout the Rub al Khali Basin. The basal Qusaiba is as thick as 75 m, with TOC values as high as to 20 percent, averaging 4 percent.

MATURATION: Qusaiba mudstones in this assessment unit are in the dry gas window over much of the central part of the basin, but are in the oil and wet gas window along the basin margins to the west, south, and east.

MIGRATION: Migration of Qusaiba hydrocarbons is considered to be mainly vertical in basement-involved structures in the central part of the basin, and moderate to long distance lateral migration is inferred along the basin margins with Unayzah sandstones as the major carrier beds.

RESERVOIR ROCKS: Reservoir rocks are mainly alluvial, fluvial, and eolian sandstones of the Permian Unayzah Formation and the basal Khuff Formation. Potential reservoirs may also be in fluvial and deltaic sandstones of the Cambro-Ordovician section. Porosity in Unayzah sandstones is as much as 30 percent, and permeabilities as high as 4 D.

TRAPS AND SEALS: Traps range from stratigraphic and structural traps along the margins of the basin to structural traps in the central part of the basin related to the major fault systems that extend across the basin. Seals are mainly anhydrites of the Khuff Formation.

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Jones, P.J., and Stump, T.E., 1999, Depositional and tectonic setting of the Lower Silurian hydrocarbon source facies, central Saudi Arabia: American Association of Petroleum Geologists Bulletin, v. 83, p. 314-332.

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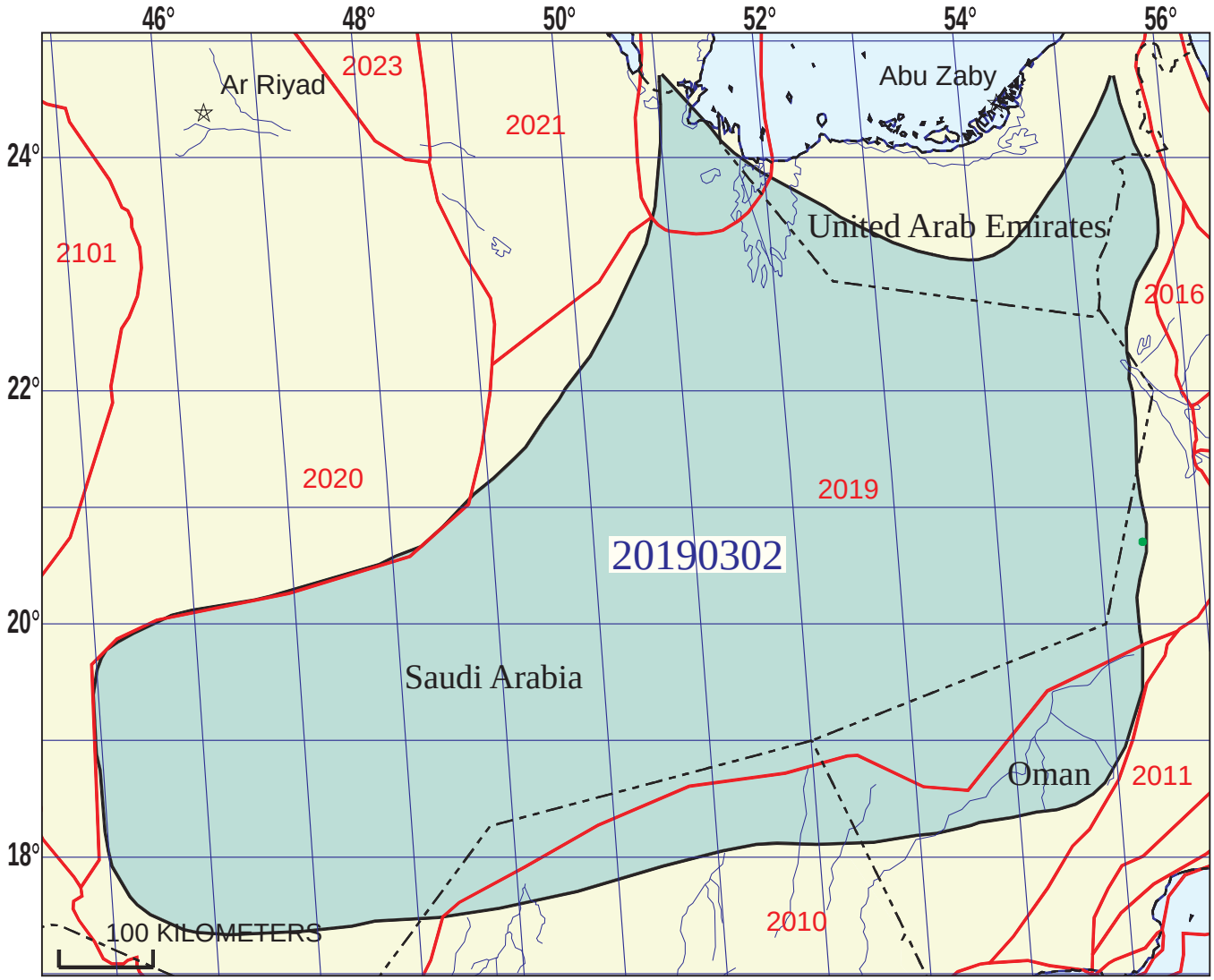


Paleozoic Reservoirs
Assessment Unit - 20190302

EXPLANATION

- Hydrography
- Shoreline
- 2019 — Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 20190302 — Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

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

Date:…….. 12/8/99
Assessment Geologist:…….. C.J. Schenk
Region:…….. Middle East and North Africa Number: 2
Province:…….. Rub Al Khali Basin Number: 2019
Priority or Boutique…… Priority
Total Petroleum System:…… Silurian Qusaiba Number: 201903
Assessment Unit:…… Paleozoic Reservoirs Number: 20190302
* Notes from Assessor This is an assessment of Permian reservoirs (assessed separately from other reservoirs), recognizing possible overlap of Jurassic and Cretaceous. Partial analog is Central Arch-Horst Block Anticlinal Oil and Gas Assessment Unit (20210101).

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: 1 Gas: 0
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 _____ 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.	45	max no.	120
Gas fields:……min. no. (>0)	10	median no.	165	max no.	400

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	50	max. size	20000
Gas in gas fields (bcfg):……min. size	60	median size	300	max. size	120000

Assessment Unit (name, no.)
Paleozoic Reservoirs, 20190302

AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS

(uncertainty of fixed but unknown values)

Oil Fields:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……	1500	3000	4500
NGL/gas ratio (bngl/mmcfg)……	30	60	90

Gas fields:	minimum	median	maximum
Liquids/gas ratio (bngl/mmcfg)……	40	80	120
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)……	35	46	55
Sulfur content of oil (%)……	0.02	0.07	0.9
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	3000	6500
Depth (m) of water (if applicable)……			

Assessment Unit (name, no.)
Paleozoic Reservoirs, 20190302

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

1. Saudi Arabia 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):...		89	
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):...		94	
Portion of volume % that is offshore (0-100%).....		0	

2. Yemen represents 4 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):...		1	
Portion of volume % that is offshore (0-100%).....		0	

3. Oman represents 7 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):.....			
Volume % in parcel (areal % x richness factor):...		3	
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):...		3	
Portion of volume % that is offshore (0-100%).....		0	

4. United Arab Emirates represents 4 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):...		2	
Portion of volume % that is offshore (0-100%).....		0	

5. Province 2019 represents 90 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		92	
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):…		98	
Portion of volume % that is offshore (0-100%)……		0	

6. Province 2010 represents 8 areal % of the total assessment unit

Oil in Oil Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		7	
Portion of volume % that is offshore (0-100%)……		0	

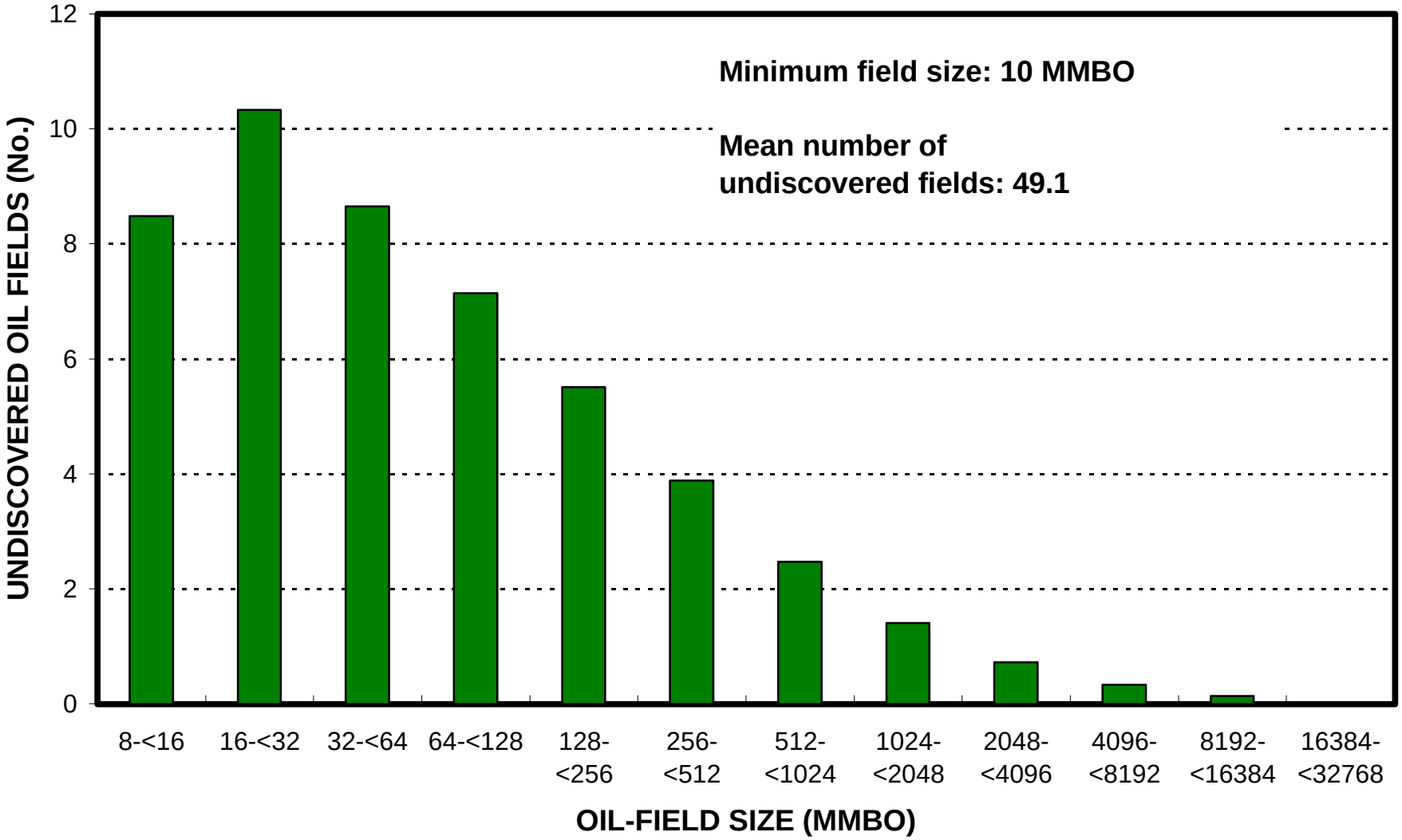
Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		1	
Portion of volume % that is offshore (0-100%)……		0	

7. Province 2022 represents 2 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%)……		0	

Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		1	
Portion of volume % that is offshore (0-100%)……		0	

Paleozoic Reservoirs, AU 20190302
Undiscovered Field-Size Distribution



Paleozoic Resevoirs, AU 20190302
Undiscovered Field-Size Distribution