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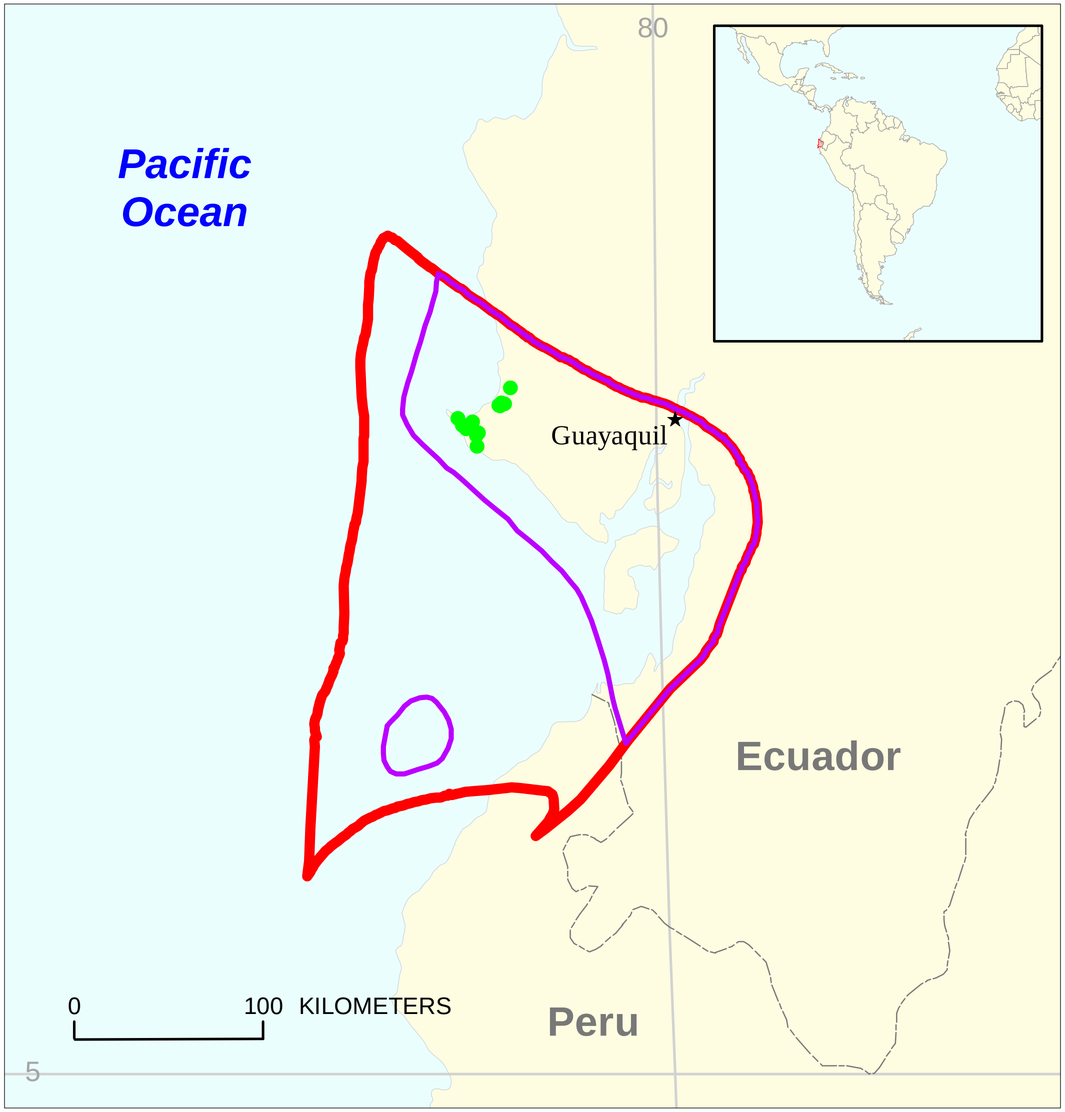
Cretaceous-Paleogene Santa Elena Block Assessment Unit 60830201



Cretaceous-Paleogene Santa Elena Block Assessment Unit 60830201

Progreso Basin Geologic Province 6083

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

U.S. GEOLOGICAL SURVEY WORLD PETROLEUM ASSESSMENT 2000— DESCRIPTION AND RESULTS
U.S. Geological Survey World Energy Assessment Team

USGS PROVINCE: Progreso Basin (6083) **GEOLOGIST:** D.K. Higley

TOTAL PETROLEUM SYSTEM: Cretaceous-Paleogene (608302)

ASSESSMENT UNIT: Cretaceous-Paleogene Santa Elena Block (60830201)

DESCRIPTION: The Progreso-Tumbes-Santa Elena Basin is located along the coast of northern Peru and southern Ecuador. The basin is divided from north to south into the Paleogene Santa Elena sub-basin, and the Neogene Progreso and Tumbes sub-basins. The Peru Bank is part of the Cretaceous-Paleogene assessment unit. Mainly oil is produced from the Cretaceous-Paleogene assessment unit. Reservoirs are primarily Eocene-age sandstones of the Santa Elena sub-basin, a Paleogene structural feature. Although they were not assessed as part of this study, offshore Ecuador and Peru exhibit excellent potential for gas hydrate resources (Miller and others, 1991).

SOURCE ROCKS: The probable hydrocarbon source rocks are marine shales that are interbedded and overlie the reservoir intervals. No source rock geochemical studies have been published regarding which marine shales may have sourced oil and gas across this basin. A probable source rock for the Santa Elena sub-basin is marine shales of the middle Cretaceous Calentura Formation (Jaillard and others, 1995).

MATURATION: Paleozoic through Tertiary source rocks across Colombia, Ecuador, and Peru became thermally mature for oil generation during Neogene phases of basin development (Pindell and Tabbutt, 1995). Miocene and younger is the probable timing of source rock maturation for Tertiary and older reservoirs across the basin (Jaillard and others, 1995; Pindell and Tabbutt, 1995). Kingston (1994) believes that the onset of oil generation could have been during late Eocene time, based largely on thickness of the stratigraphic section in the basin.

MIGRATION: Probable onset of migration is mid-Miocene time, after the opening of the Gulf of Guayaquil by movement along the Dolores-Guayaquil megashear and creation of the Progeso-Tumbes sub-basin. Close association of potential source and reservoir rocks suggests that emplacement of oil in reservoirs could have begun soon after the start of hydrocarbon generation.

RESERVOIR ROCKS: The Santa Elena sub-basin produces from mostly Eocene reservoirs of the Altanta sandstone/Olistrostrome. Two fields in the Santa Elena sub-basin produce from both the Quaternary Tablazo Formation and Eocene formations; since Quaternary shales are probably immature for oil the source could have been Eocene or other Tertiary marine shales, or those of underlying Late Cretaceous shales. These formations are also potential reservoir rocks in the Peru Bank, a wedge of Paleogene-Paleozoic sediments that were isolated from the Neogene erosion that removed these strata from most of the Tumbes and Progreso sub basins. Sedimentary thickness at Peru Bank is about 16,000 m (52,000 ft) (Zuniga-Rivero and others, 1999).

TRAPS AND SEALS: While the Progreso-Tumbes-Santa Elena Basin has been characterized as a forearc basin, it lies seaward of the Coastal range, which has been identified as a “trench-slope break" or "outer-arc ridge" environment; Kingston (1994) indicates a closer basin configuration might be named trench-slope basin. Evidence for growth faulting in the Progresso Basin is mostly in lower Miocene, Oligocene, Eocene, and Paleocene formations on top of the metamorphosed Pennsylvanian Amotape and Precambrian basement rocks (AIPC, no date). Some of the tectonic events that influenced hydrocarbon generation, migration, and trap formation are listed below:

1. Early-middle Eocene boundary–New fore-arc basins were created. This is attributed to collision of coastal Ecuador with the Andean margin.
2. Eocene–Inca Orogeny–This is the period of erosion of the Cretaceous section in Progreso and Tumbes that involves right-lateral and rotational movement associated with the Dolores-Guayaquil megashear and possibly the Troncho Mocho wrench fault. This Eocene event resulted in emergence of the southern coastline of Ecuador (Santa Elena peninsula) (Jaillard and others, 1995)
3. Upper Oligocene-Miocene time–Separation of the Nazca Plate from the South American Plate with active subduction at the Peru-Chile trench and creation of the Neogene (Tumbes, Progreso) fore-arc basins (Jaillard and others, 1995) and deposition of the thick Miocene section.
4. Middle Miocene–Block faulting across the Progreso and Talara basins and renewed growth of the Andes Mountains.
5. Mid-Pliocene–Horst and graben, gravity and basement-involved faulting, mostly in the Tumbes sub-basin (AIPC, no date).

Overlying and interbedded marine shales are the major reservoir seals, both for shallow and deepwater deposits. Lateral seals are (primarily normal) fault offsets, and lateral depositional or erosional pinchout of the mostly marine sandstones into shales. Sediment sources are mainly from the east, northeast, and southeast (Petroperu, 1999; Pindell and Tabbutt, 1995), depositional patterns associated with these fluvial, shoreline, turbidite, marine and other facies strongly influence types and locations of seals.

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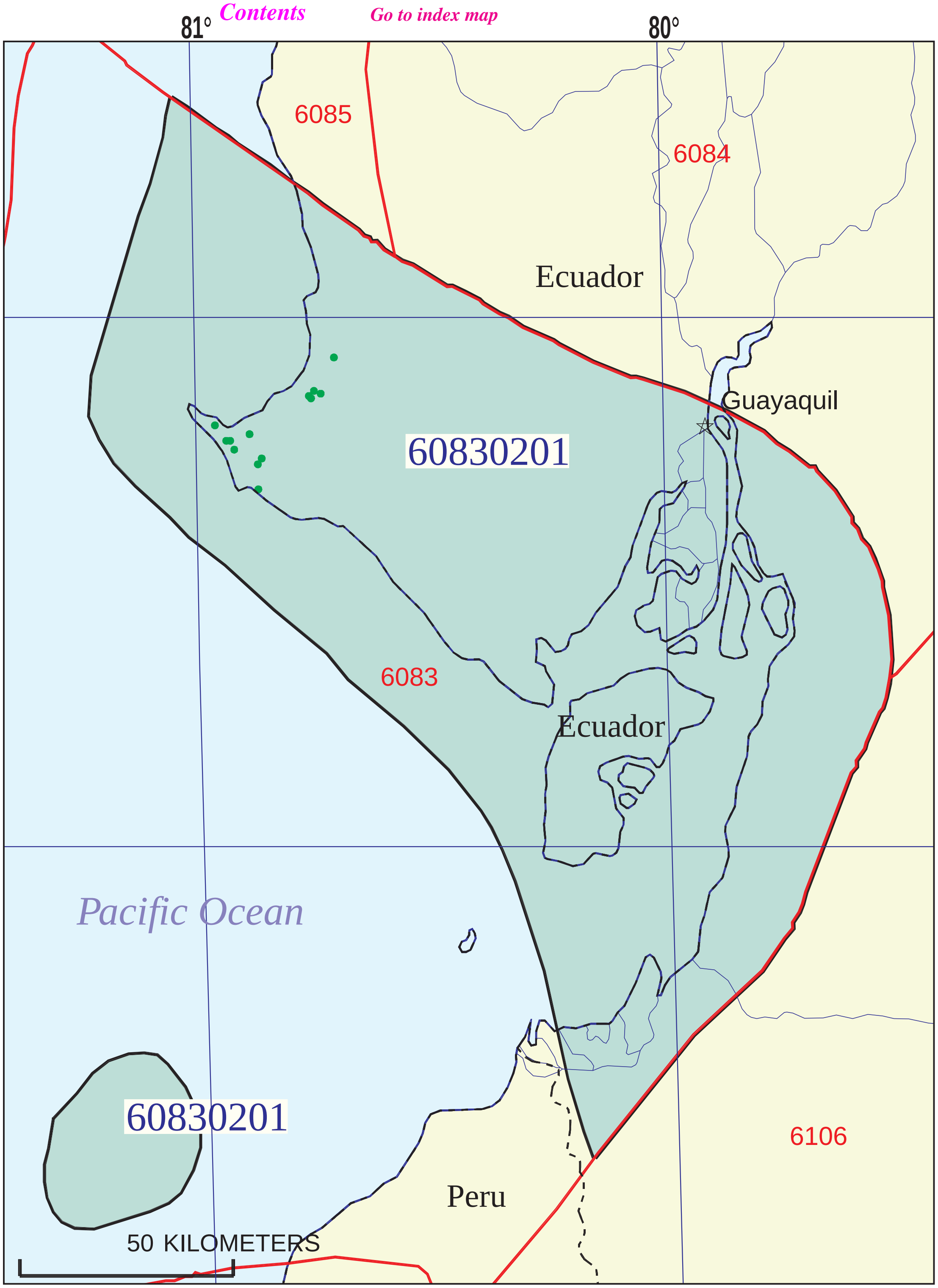

Cretaceous-Paleogene Santa Elena Block Assessment Unit - 60830201

EXPLANATION

- Hydrography
- Shoreline
- 6083 Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 60830201 Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

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

Date:………………………….	12/17/99		
Assessment Geologist:……..	D.K. Higley		
Region:………………………..	Central and South America	Number:	6
Province:………………………	Progreso Basin	Number:	6083
Priority or Boutique…………	Boutique		
Total Petroleum System:……	Cretaceous-Paleogene	Number:	608302
Assessment Unit:……………	Cretaceous-Paleogene Santa Elena Block	Number:	60830201
* Notes from Assessor	MMS 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?………. 1 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: 7 Gas: 0
Established (>13 fields) ____ Frontier (1-13 fields) X Hypothetical (no fields) ____

Median size (grown) of discovered oil fields (mmboe):
1st 3rd 4.1 2nd 3rd 27.9 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)

	min. no. (>0)	median no.	max no.
Oil fields:…………………………………	1	20	45
Gas fields:………………………………	1	3	6

Size of Undiscovered Fields: What are the anticipated sizes (**grown**) of the above fields?:
(variations in the sizes of undiscovered fields)

	min. size	median size	max. size
Oil in oil fields (mmbo)………………..……	1	4	300
Gas in gas fields (bcfg):……………………	6	18	600

Assessment Unit (name, no.)
Cretaceous-Paleogene Santa Elena Block, 60830201

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	600	1000
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)……………………………….	18	34	48
Sulfur content of oil (%)…………………………..…..	0.05	0.26	0.5
Drilling Depth (m) …………….....……………………..	100	1500	4500
Depth (m) of water (if applicable)…………….....…..	0	200	1000

Gas Fields:	minimum	median	maximum
Inert gas content (%)……………………….....…….			
CO_2 content (%)……………………………….....…..			
Hydrogen-sulfide content (%)……………….....…….			
Drilling Depth (m)……………………………………..	1500	2500	5000
Depth (m) of water (if applicable)………………….	0	200	1000

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Assessment Unit (name, no.)
Cretaceous-Paleogene Santa Elena Block, 60830201

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

1. Ecuador 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%)……		80	

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%)……		80	

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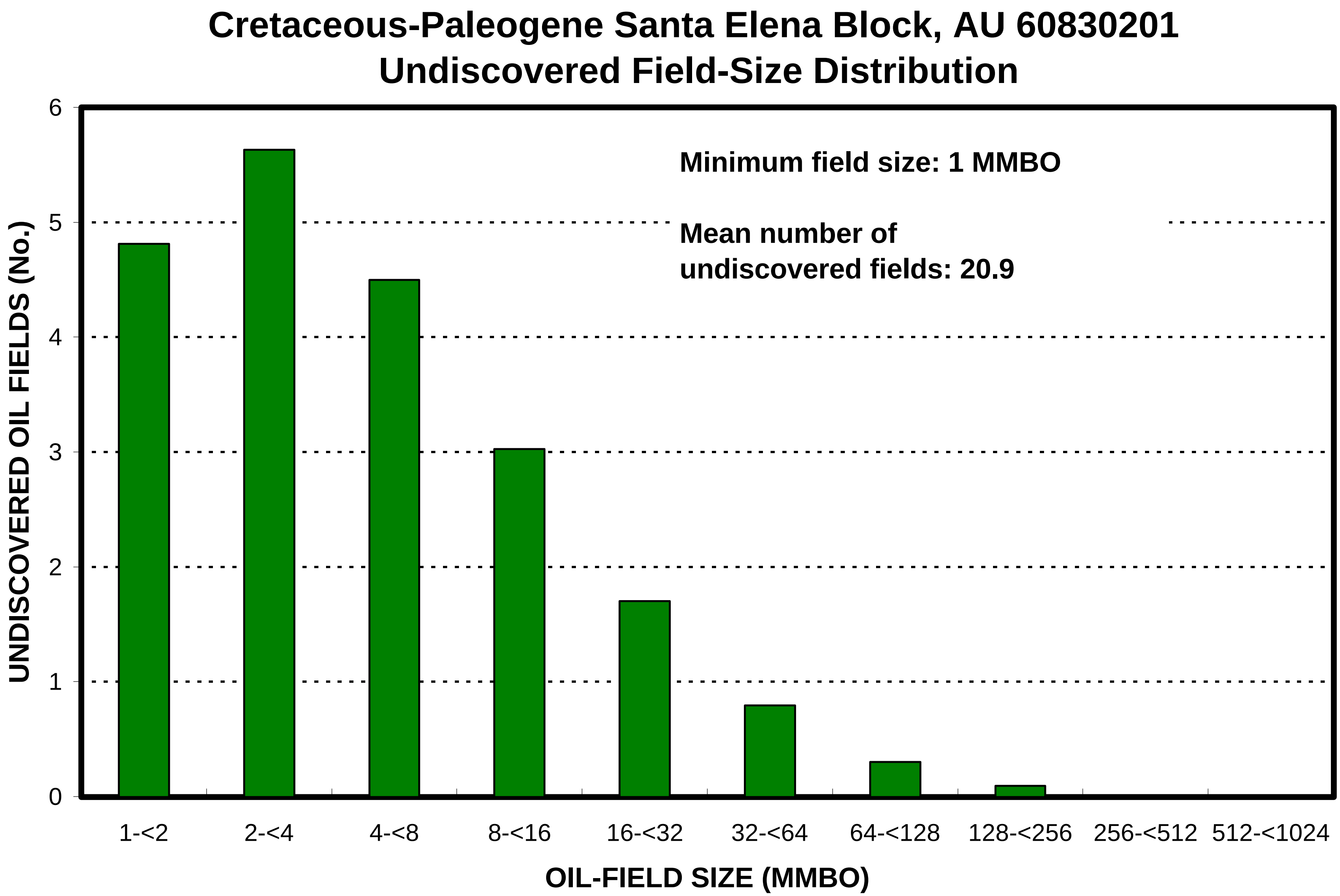
Cretaceous-Paleogene Santa Elena Block, AU 60830201
Undiscovered Field-Size Distribution
Minimum field size: 1 MMBO
Mean number of undiscovered fields: 20.9
UNDISCOVERED OIL FIELDS (No.)
0
1
2
3
4
5
6
1-<2
2-<4
4-<8
8-<16
16-<32
32-<64
64-<128
128-<256
256-<512
512-<1024
OIL-FIELD SIZE (MMBO)

Cretaceous-Paleogene Santa Elena Block, AU 60830201
Undiscovered Field-Size Distribution