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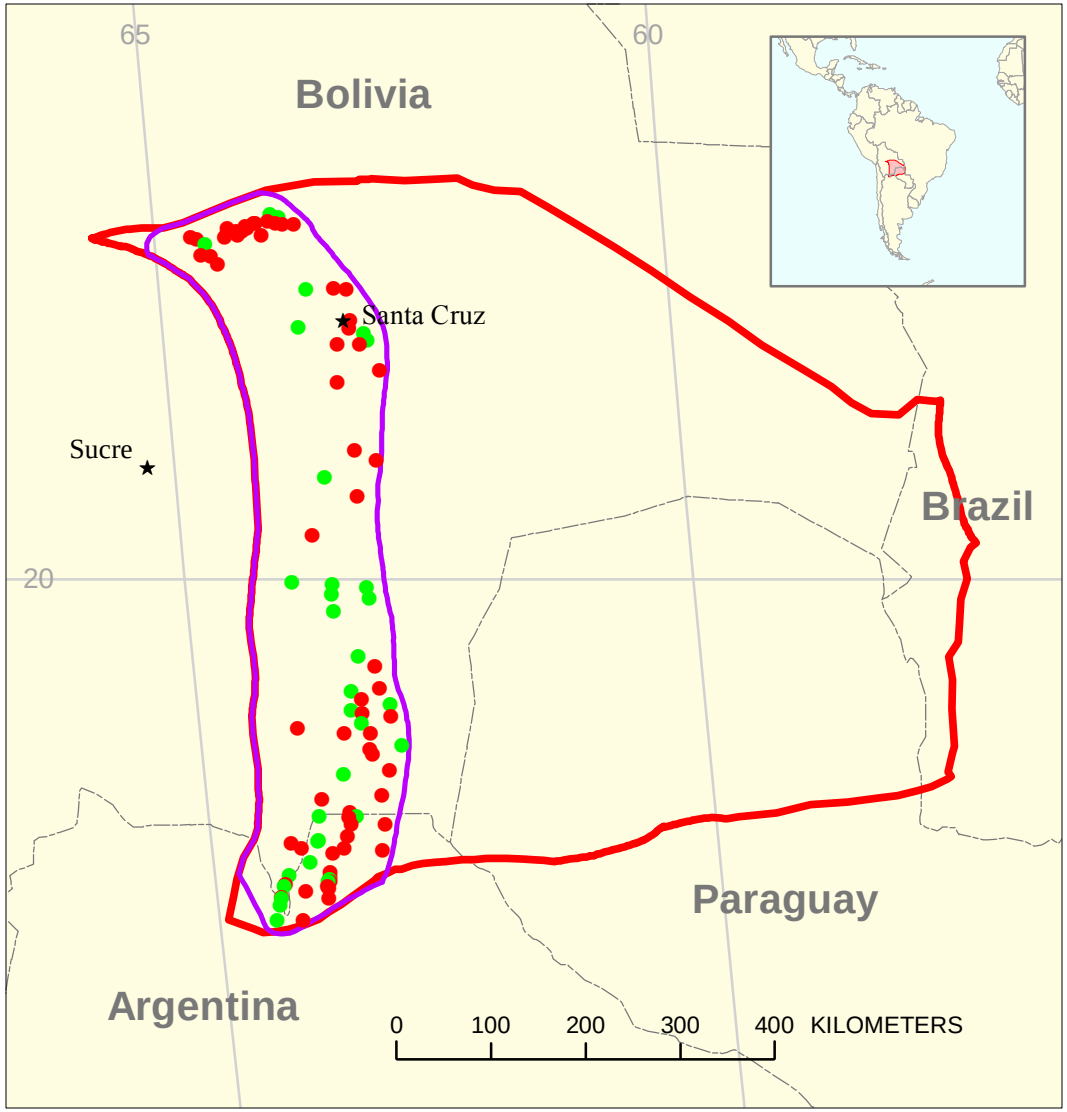
Sub-Andean Fold and Thrust Belt Assessment Unit 60450101



USGS PROVINCE: Santa Cruz-Tarija Basin (6045) **GEOLOGIST:** S.J. Lindquist

TOTAL PETROLEUM SYSTEM: Los Monos-Machareti (604501)

ASSESSMENT UNIT: Sub-Andean Fold and Thrust Belt (60450101) (established)

DESCRIPTION: The Santa Cruz-Tarija Province comprises a Paleozoic intracratonic rift basin that evolved into a Tertiary thin-skinned thrust belt and foreland basin. This assessment unit includes the easternmost surface expression of an eastern salient of the Andean thrust system, located in southeastern Bolivia and northwestern Argentina. It is approximately 111,000 sq km in area.

SOURCE ROCKS: Primary Devonian Los Monos and secondary Silurian Kirusillas (El Carmen) oil-and-gas-prone shales attain composite maximum thicknesses of 4 km and are present in the entire area of the assessment unit. The shales were deposited in semi-restricted, marine extensional basins and contain Type II to Type III kerogens and a maximum TOC content of 2 wt. %.

MATURATION: Assessment unit contains the lowest thermal gradients for the province, and the top of the oil window is approximately 5.5 km at present. Because of variable sub-Andean stratigraphic and tectonic overburden, local expulsion could have occurred at times ranging from 270 Ma (Early Permian) to approximately 10 Ma (Late Miocene).

MIGRATION: Short-distance, updip lateral migration from thermally mature synclines into anticlines, with local fault transmission of fluids. Andean remigration from older accumulations is possible.

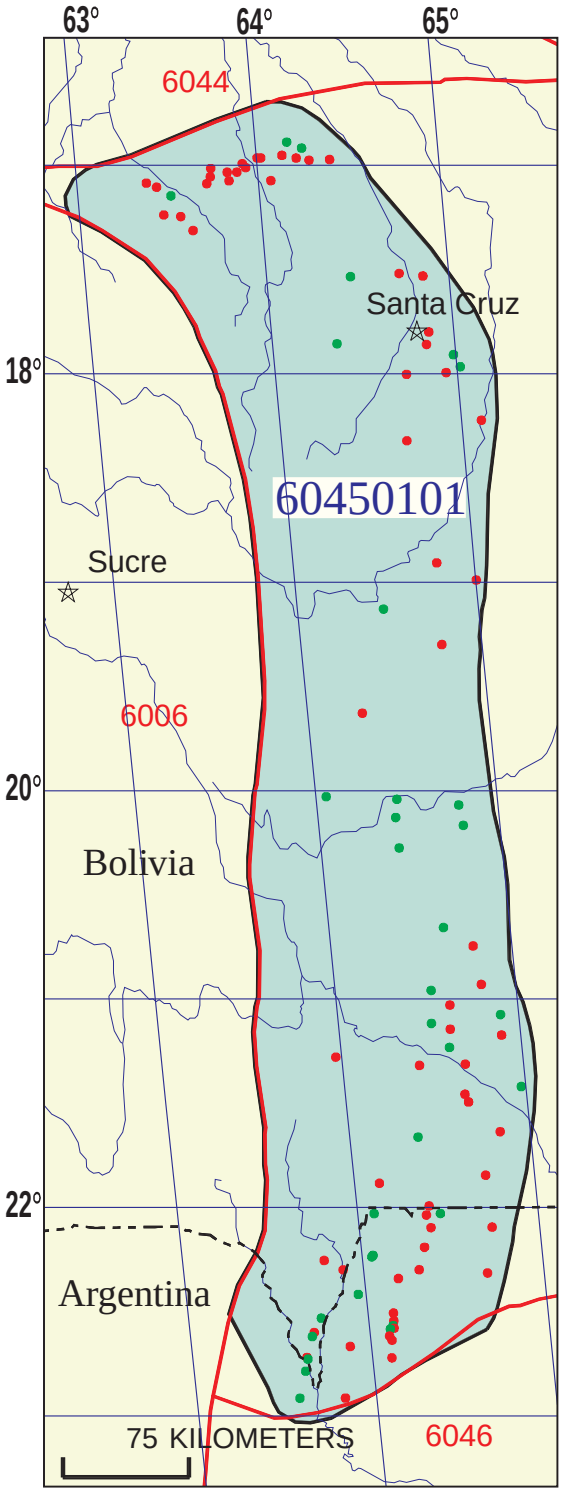
RESERVOIR ROCKS: Reservoirs of all stratigraphic ages (Silurian through Tertiary) produce in the fold and thrust belt, with arithmetic average reservoir properties ranging from 10 to 23 percent for porosity and 10 to 200 mD for permeability. Carboniferous, glacially influenced fluvial-to-submarine siliciclastic channel deposits contain most reserves and exhibit 20 percent porosities and 100 to 150 mD permeabilities.

TRAPS AND SEALS: Traps are primarily thin-skinned, thrusted and faulted anticlines formed during the Late Cretaceous to Pliocene Andean orogeny. Deformation within this assessment unit is older and more complex westward but largely Miocene in age. Seals are local and regional Paleozoic marine shales ranging from 10 to >1000 m in thickness and glacial diamictites tens to hundreds of meters thick.

REFERENCES:

Lindquist, S.J., 1998, The Santa Cruz-Tarija province of central South America—Los Monos-Machareti(!) petroleum system: U.S. Geological Survey Open-File Report 99-50-C, 16 p., 11 figs., 1 table.

Tankard, A.J., Suarez S., R., and Welsink, H.J., eds., 1995, Petroleum basins of South America: American Association of Petroleum Geologists Memoir 62, 792 p.



Sub-Andean Fold and Thrust Belt Assessment Unit - 60450101

EXPLANATION

- Hydrography
- Shoreline
- 6045 — Geologic province code and boundary
- Country boundary
- Gas field centerpoint
- Oil field centerpoint
- 60450101 — Assessment unit code and boundary

Projection: Robinson. Central meridian: 0

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

Date:……..	3/4/99		
Assessment Geologist:……..	C.J. Schenk		
Region:……..	Central and South America	Number:	6
Province:……..	Santa Cruz-Tarija Basin	Number:	6045
Priority or Boutique……	Priority		
Total Petroleum System:……	Los Monos-Machareti	Number:	604501
Assessment Unit:……..	Sub-Andean Fold and Thrust Belt	Number:	60450101
* Notes from Assessor	Rocky Mountain (US Region 4) growth factor.		

CHARACTERISTICS OF ASSESSMENT UNIT

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

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: 20 Gas: 56

Established (>13 fields)	Frontier (1-13 fields)	Hypothetical (no fields)
X		

Median size (grown) of discovered oil fields (mmboe):

1st 3rd	2nd 3rd	3rd 3rd
3.7	10.9	2.6

Median size (grown) of discovered gas fields (bcfg):

1st 3rd	2nd 3rd	3rd 3rd
140	118	148

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)	6	median no.	35	max no.	70
Gas fields:……min. no. (>0)	30	median no.	100	max no.	170

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	1	median size	3	max. size	85
Gas in gas fields (bcfg):……	min. size	6	median size	80	max. size	6000

Assessment Unit (name, no.)
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AVERAGE RATIOS FOR UNDISCOVERED FIELDS, TO ASSESS COPRODUCTS

(uncertainty of fixed but unknown values)

Oil Fields:	minimum	median	maximum
Gas/oil ratio (cfg/bo)……	1375	2750	4125
NGL/gas ratio (bngl/mmcfg)……	30	60	90

Gas fields:	minimum	median	maximum
Liquids/gas ratio (bngl/mmcfg)……	19	38	57
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	45	55
Sulfur content of oil (%)……	0.01	0.08	0.16
Drilling Depth (m) ……	1200	3000	5000
Depth (m) of water (if applicable)……			

Gas Fields:	minimum	median	maximum
Inert gas content (%)……			
CO_2 content (%)……			
Hydrogen-sulfide content(%)……			
Drilling Depth (m)……	2000	4500	7000
Depth (m) of water (if applicable)……			

Assessment Unit (name, no.)
Sub-Andean Fold and Thrust Belt, 60450101

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

1. Bolivia 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):…		93	
Portion of volume % that is offshore (0-100%)……		0	

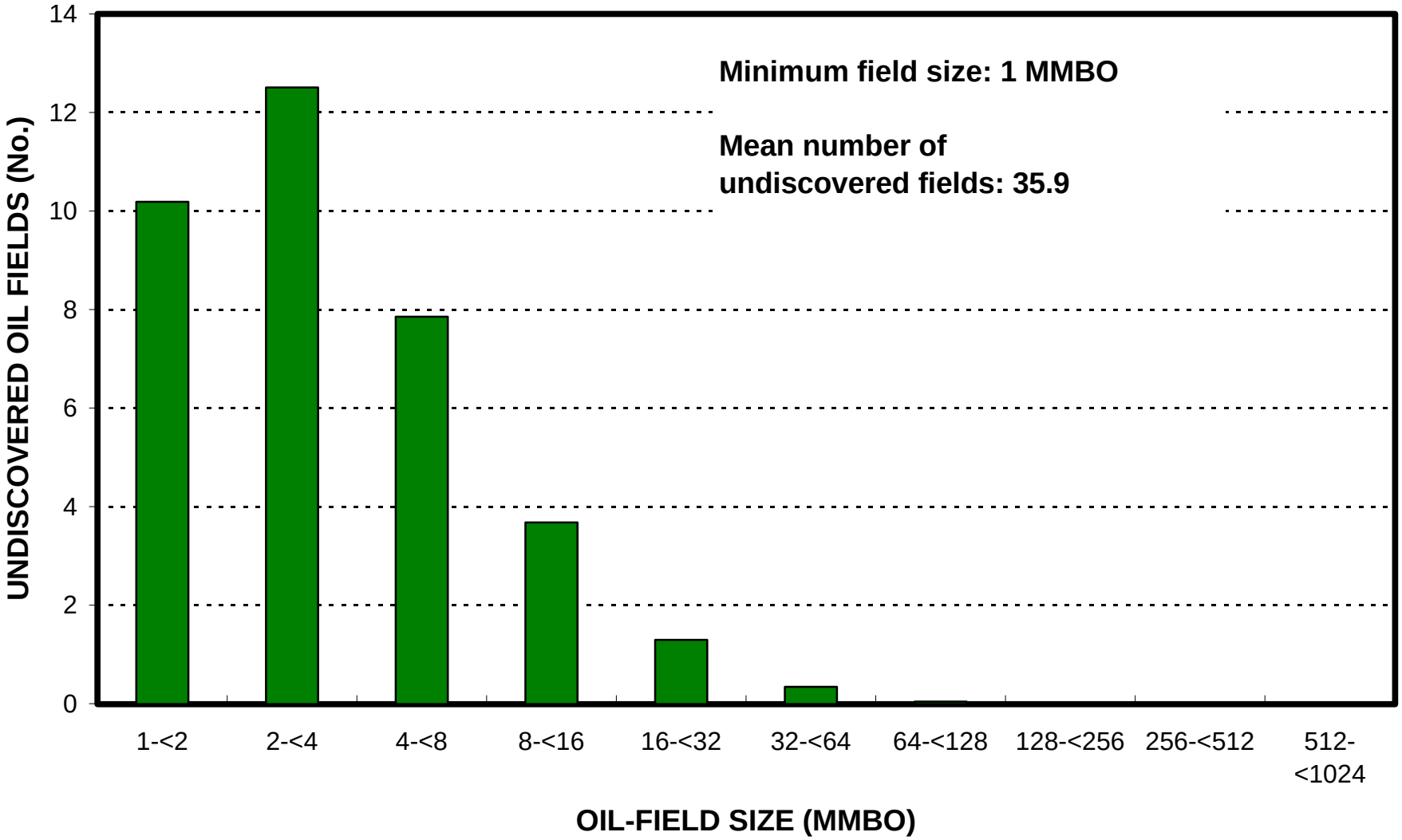
Gas in Gas Fields:	minimum	median	maximum
Richness factor (unitless multiplier):……			
Volume % in parcel (areal % x richness factor):…		93	
Portion of volume % that is offshore (0-100%)……		0	

2. Argentina 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):…		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):…		7	
Portion of volume % that is offshore (0-100%)……		0	

Sub-Andean Fold and Thrust Belt, AU 60450101
Undiscovered Field-Size Distribution



Sub-Andean Fold and Thrust Belt, AU 60450101
Undiscovered Field-Size Distribution