

Global Distribution of Petroleum Reserves in Deep Reservoirs*

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Abstract

Exploration for deep petroleum accumulations, which refer to those at burial depths of no less than 15,000 ft (about 4,572 m), deserves more specialized attention. Excluding US onshore Lower 48 States, 87 major sedimentary basins are identified to host deep petroleum accumulations throughout the world. North America contains the largest quantities of the discovered deep petroleum with original proved plus probable (2P) reserves of 28,060 MMBOE. The three most prolific basins for deep petroleum are the Gulf of Mexico, Arabian and East Venezuela Basins, and they contain 48.6% of the total deep original 2P petroleum reserves in the world. 63.3% of the total are reservoirized in clastic rocks, 35.0% in carbonates and 1.7% in crystalline rocks. In terms of trap type, 95.7% of the total are entrapped in structural and combination traps. Passive margin and foreland basins contain the bulk of the deep original 2P petroleum reserves in the world, with the former accounting for 47.7% of the total and the latter 46.4%. Salt-bearing deep sedimentary basins are significantly more prospective for deep petroleum than basins without salt, which is attributed to the relative cooling effect for the subsalt sediments induced by salt and associated salt structures. The effect is responsible for retardation of source rock maturation in the deep parts of petroliferous basins. The petroliferous basins in the Tethyan realm contain 85.0% of the world total deep original 2P petroleum reserves, which is similar to the distribution of petroleum in shallow-intermediate reservoirs. 92.3% of the total occurs in reservoirs with burial depths of 15,000 ft (about 4,572 m) to 20,000 ft (about 6,096 m). Stratigraphically, the deep petroleum reserves are largely confined to five reservoir intervals: Neogene (hosting 22.3% of the total), Upper Paleozoic (22.2%), Cretaceous (18.4%), Paleogene (12.8%) and Jurassic (12.8%). The concentration of deep petroleum reserves in the Jurassic-Tertiary reservoir rocks may be a direct result of widespread availability of more effective source rocks in these stratigraphic intervals. There exists an objective similarity in the stratigraphic distribution of generated and trapped original reserves for both deep and shallow-intermediate petroleum. Therefore, we suggest that the deep petroleum exploration should target the play fairways where substantial shallow-intermediate petroleum reserves have already been discovered.

Selected References

Ingersoll, R.V., and C.J. Busby, 1995, Tectonics of sedimentary basins: in C.J. Busby and R.V. Ingersoll, eds., Tectonics of sedimentary basins. Oxford, Blackwell Science, p. 1–51.

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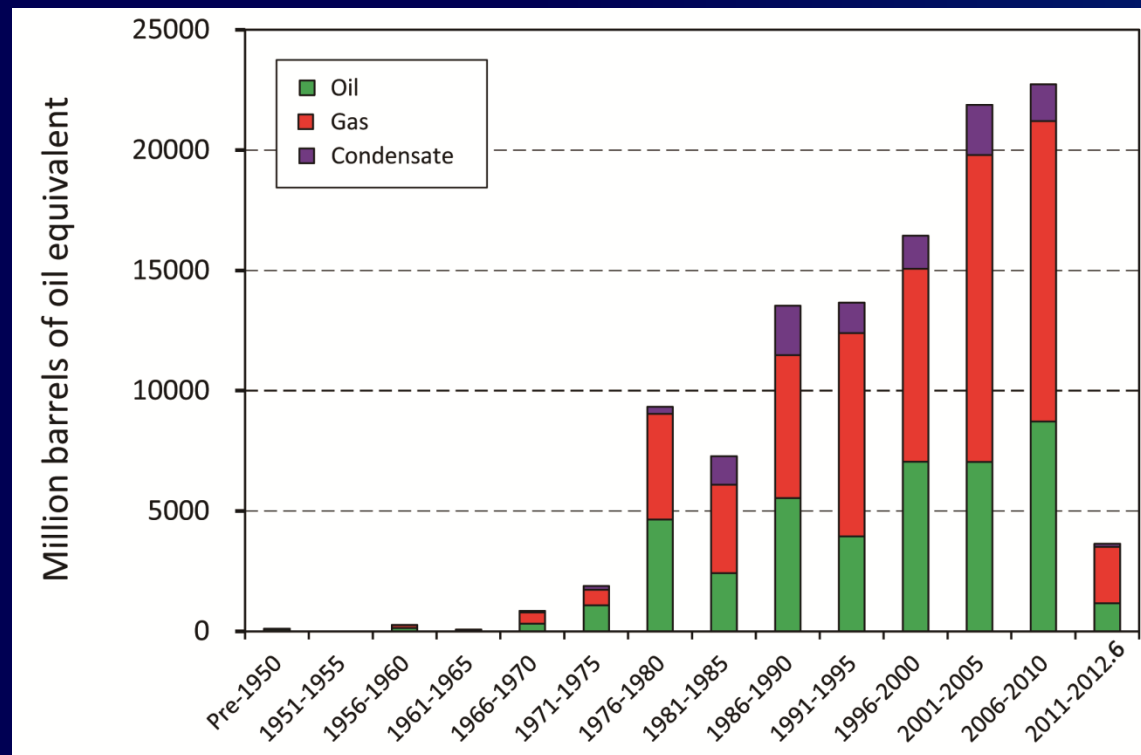
Outline

- Introduction
- Geological characteristics of deep petroleum accumulations
- Distribution of deep petroleum
- Comparison between deep and shallow-intermediate petroleum
- Conclusion

Introduction

Deep petroleum is defined as oil and/or gas occurring in reservoirs at burial depths of **no less than 15,000 ft** (Dyman et al., 2002)

Exploration for deep petroleum deserves more specialized attention

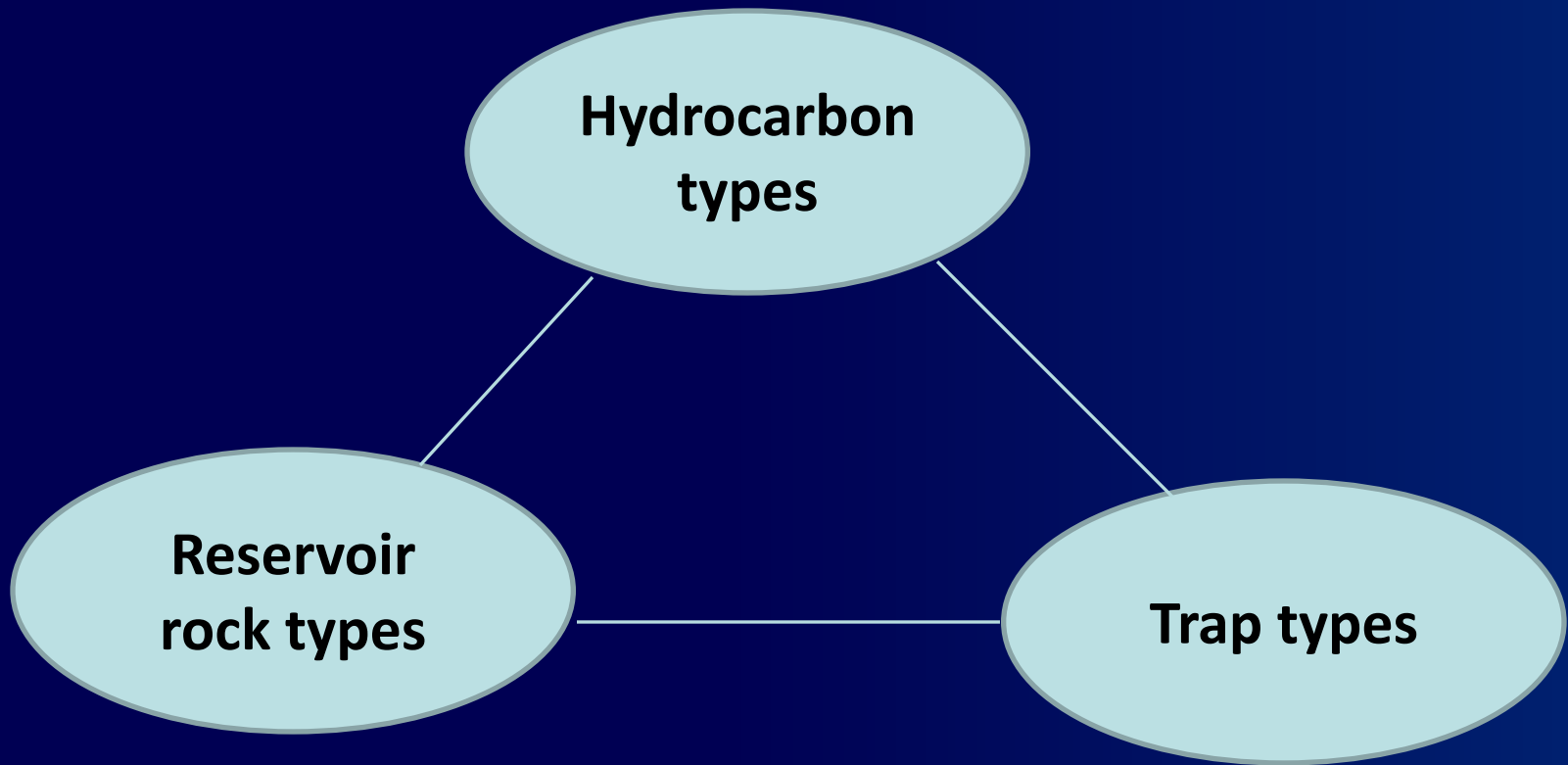


Discovery history of worldwide deep petroleum, excludes onshore Lower 48 States (Unconventional resources are not counted)

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General geological characteristics of deep petroleum



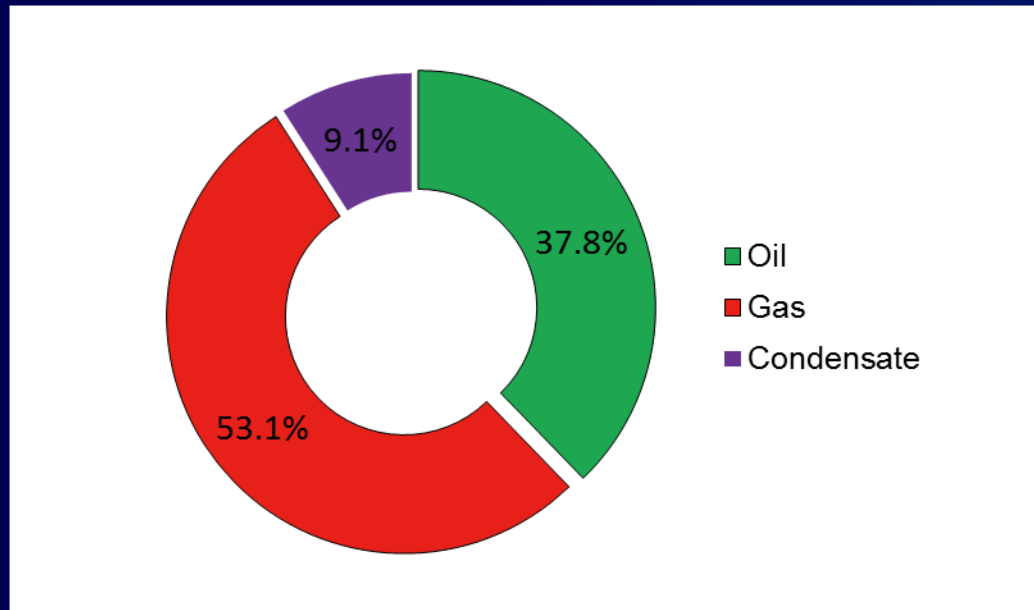
General geological characteristics—hydrocarbon types

Deep oil: 42 BBO (making up 1.9% of the world total oil)

Deep gas: 356 TCF (3.6%)

Deep condensate: 10 BBC (2.1%)

Total: 111670 MMBOE

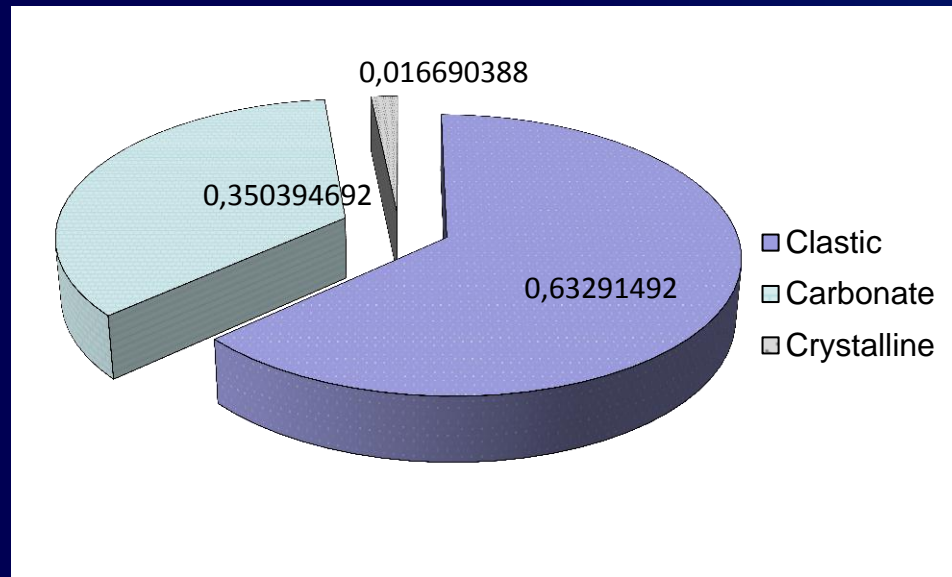


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General geological characteristics—reservoir rock types

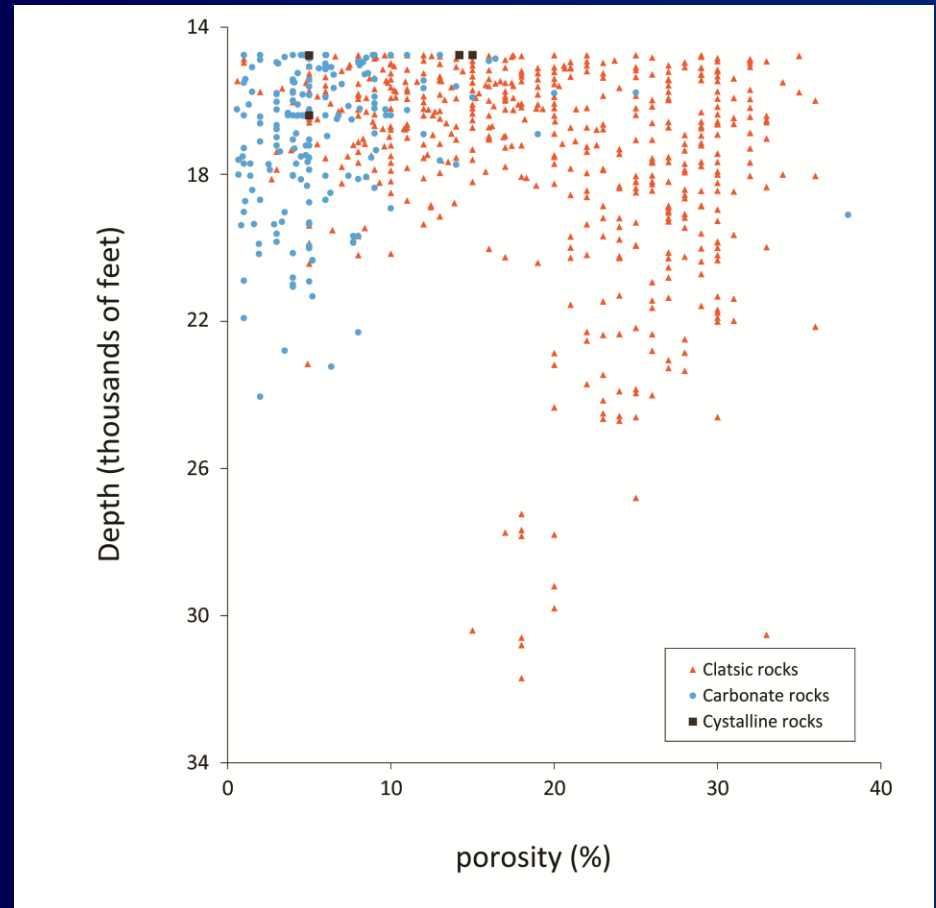
Clastic rocks, carbonate, igneous and metamorphic rocks



General geological characteristics—reservoir rock types

Clastic reservoirs exhibit the highest porosities

All prolific reservoirs deeper than 24,000 ft are sandstone, and have the porosities of 18%-30%



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General geological characteristics—trap types

Structural: 73.8% of the total

Combination: 21.9%

Stratigraphic traps: 4.4%

It is truly unadvisable that stratigraphic traps should be ignored and even avoided in deep petroleum exploration

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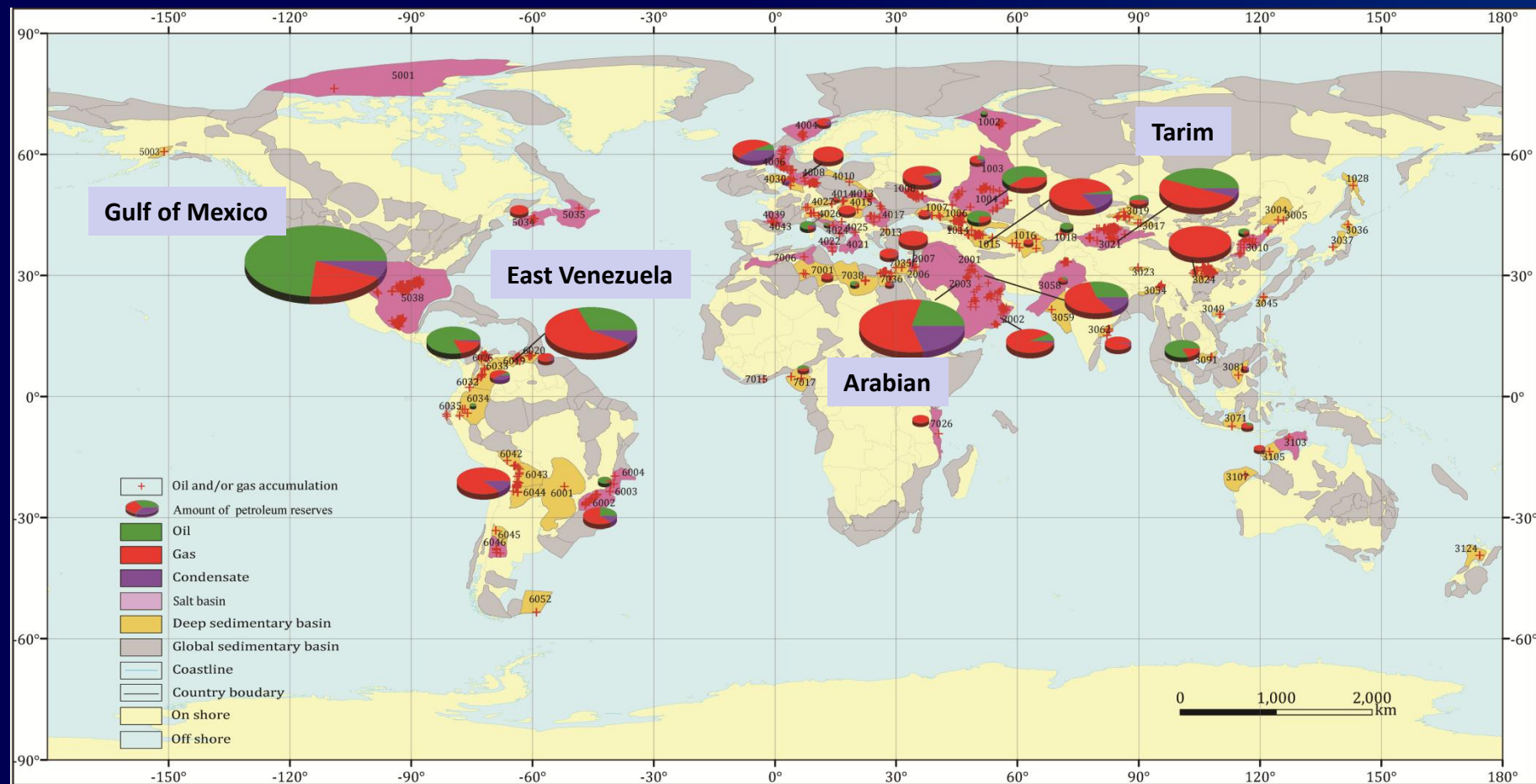
Distributions of deep petroleum

Excluding onshore Lower 48 States, we have identified 87 major basins containing discovered deep petroleum of 349 sedimentary basins in the entire world, amounting to 1595 fields or pools

The distributions of deep oil, gas and condensate by

- 1) Geographic region
- 2) Basin type
- 3) Burial depth
- 4) Stratigraphic interval

Distributions by geographic regions



Distribution map of deep basins and deep petroleum accumulations

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Distributions by geographic regions

North America contains the largest quantities, followed by Middle East and then Central and South America

North America is the most prolific for deep oil reserves

Middle East has the largest share of deep gas and condensate reserves

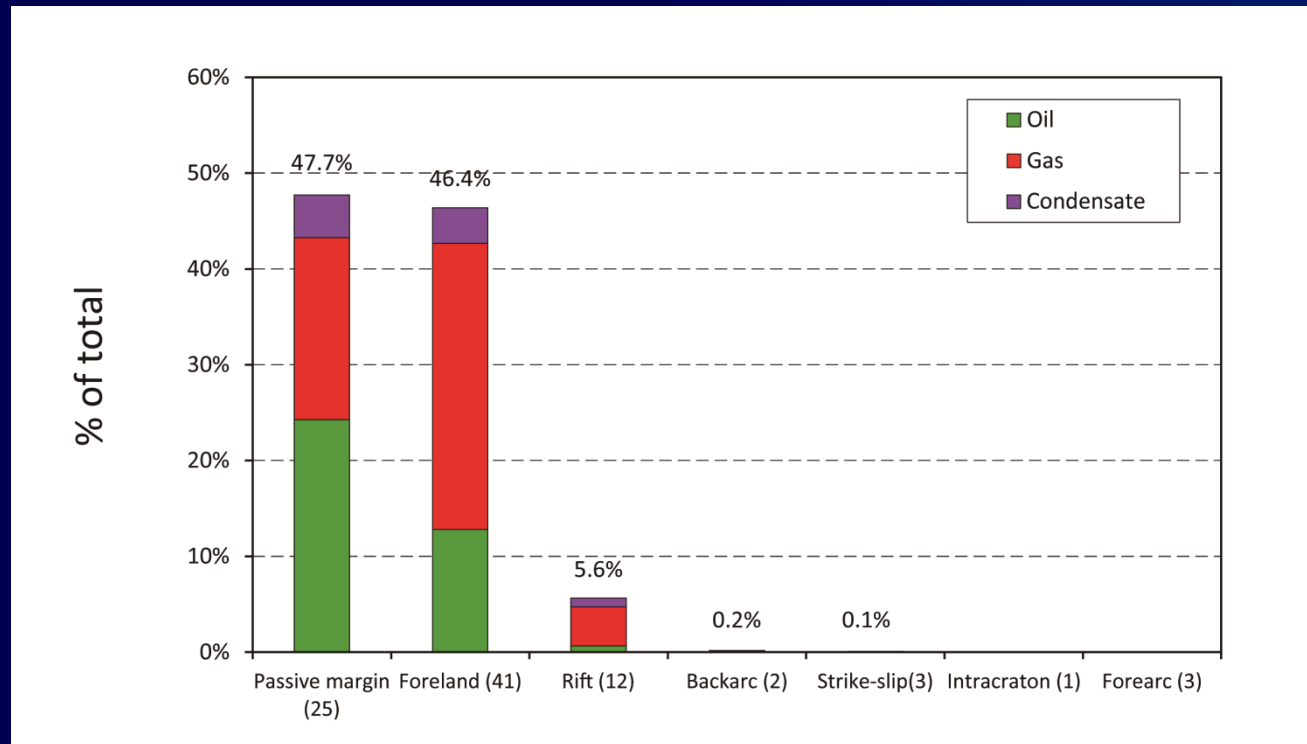
Region	Original 2P Oil Reserve (MMBO)	Original 2P Gas Reserve (BCF)	Original 2P Condensate Reserve (MMBC)	MMBOE
Former Soviet Union	2,880	47,727	1,134	11,968
Europe	548	20,210	1,022	4,939
Asia Pacific	5,696	69,294	620	17,866
North America	20,225	37,415	1,600	28,060
Central and South America	7,555	77,282	1,830	22,265
Africa	207	7,469	51	1,503
Middle East	5,071	96,701	3,881	25,069
World	42,183	356,098	10,137	111,670

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Distributions by basin types

Passive margin and foreland basins contain the bulk of the world total



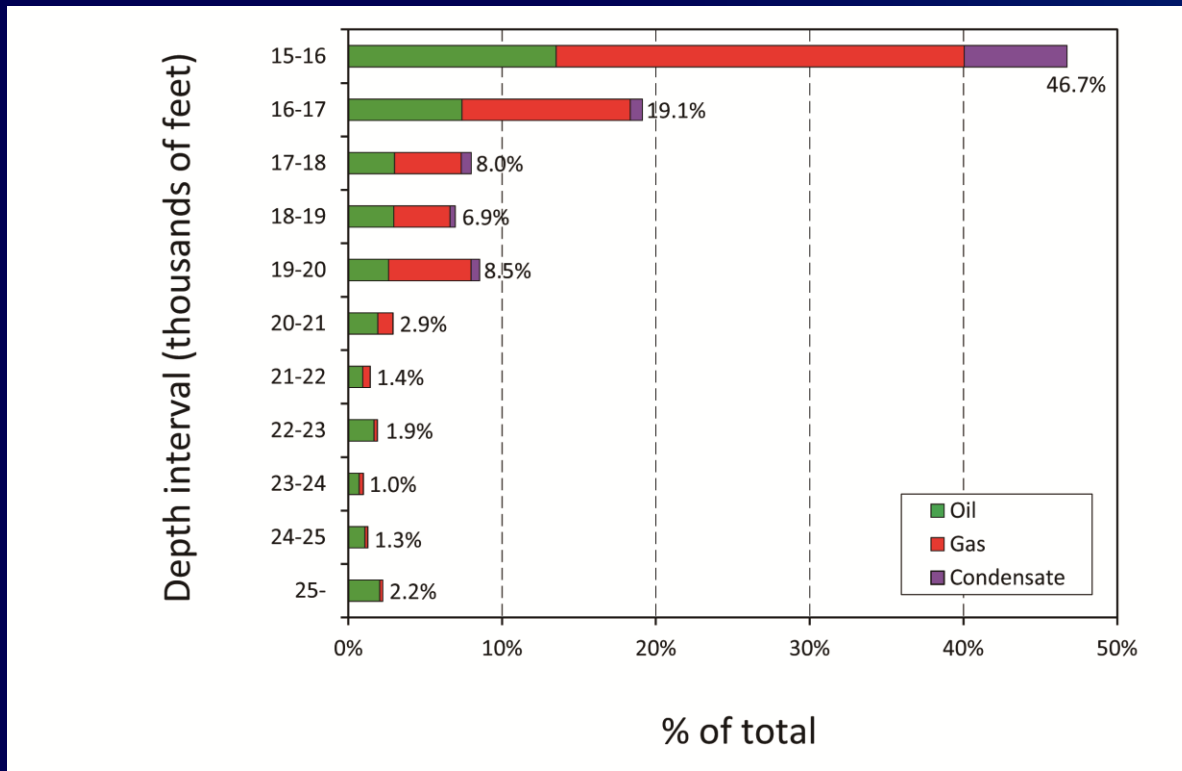
The basin classification is from Ingersoll and Busby (1995)

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Distributions by burial depth

92.3% of the world total occur in the burial depth interval of 15,000 ft to 20,000 ft

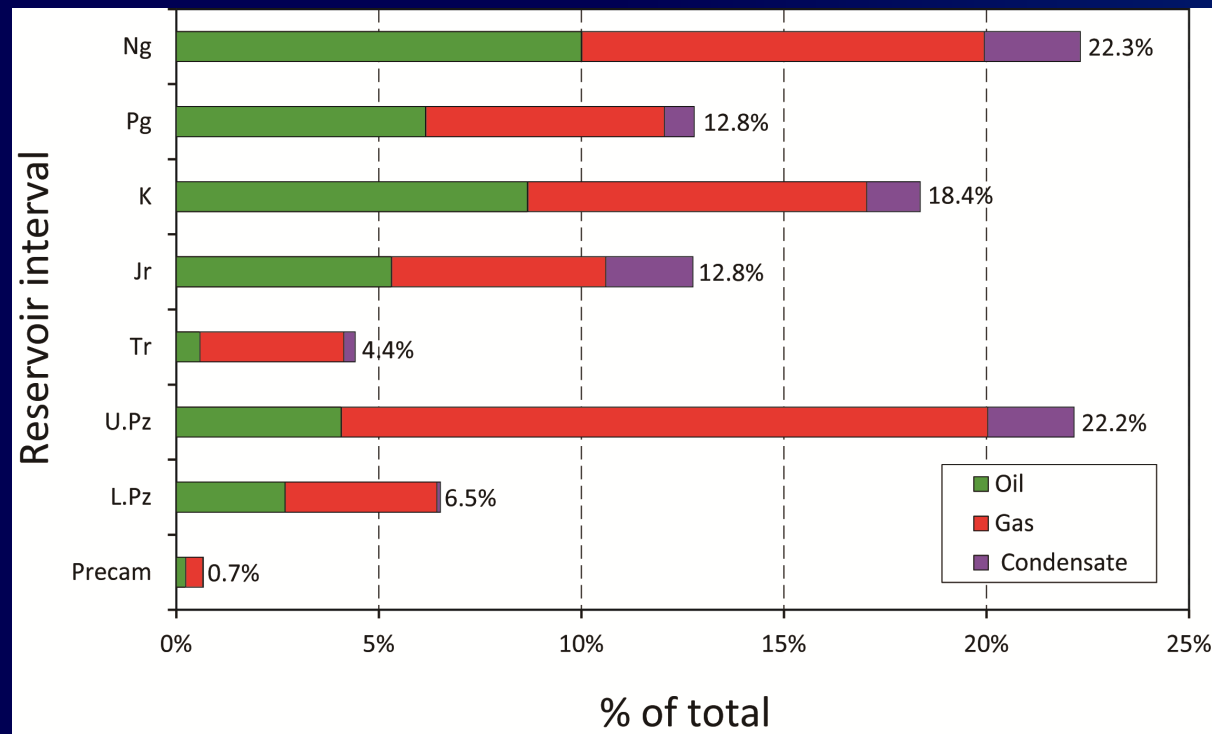


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Distributions by stratigraphic interval

The more prolific intervals are Neogene, Upper Paleozoic, Cretaceous, Paleogene and Jurassic, containing 88.4 % of the world total. Older reservoirs are still highlighted as significant targets for gas.



Salt deposits

33 of the 87 deep sedimentary basins are salt basins

These 33 salt basins contain 65.8% of the world total deep petroleum, emphatically, with deep oil reserves accounting for 75.9% of the world total deep oil

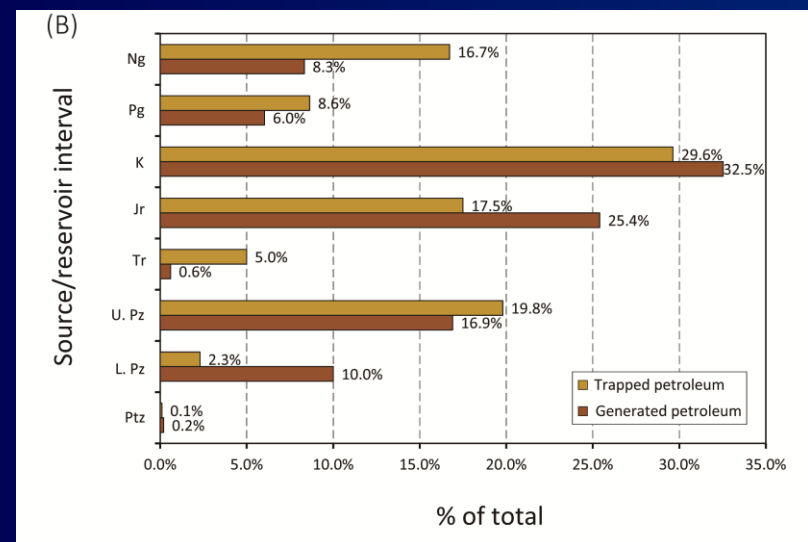
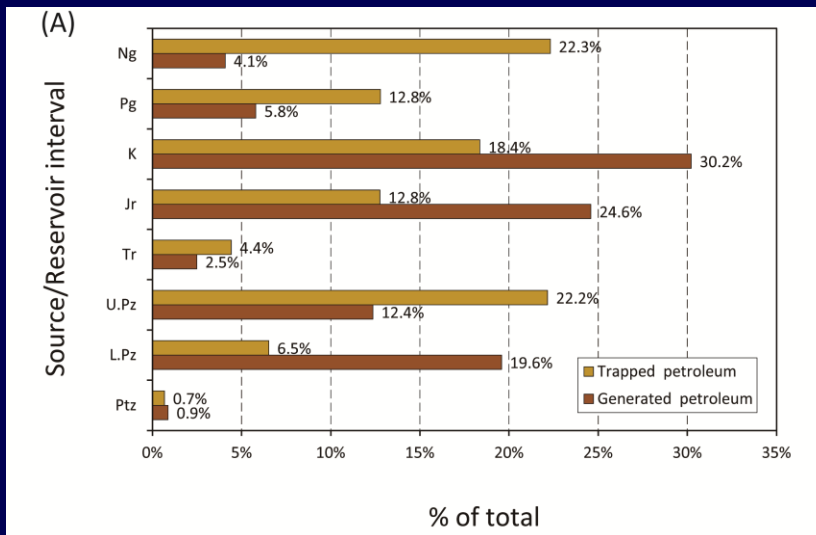
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Roles of stratigraphic age

The concentration in the Jurassic-Tertiary reservoir rocks may be a direct result of widespread availability of more effective source rocks

The older source intervals generally contributed smaller than younger ones



Generated versus trapped deep petroleum reserves in stratigraphic column

(A) Deep petroleum

(B) Shallow-intermediate petroleum

(modified from Klemme & Ulmishek (1991) 厚积薄发 开物成务

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Comparison between deep and shallow-intermediate petroleum

There exists an objective similarity in the stratigraphic distribution of generated and trapped original reserves for both deep and shallow-intermediate petroleum

The areas where substantial shallow-intermediate petroleum reserves have already been discovered tend to have greater exploration potentials for deep petroleum

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Conclusion 1

North America contains the largest quantities of the discovered deep petroleum. The four most prolific basins for deep petroleum are the Gulf of Mexico, Arabian, East Venezuela and Tarim Basins

63.3% of the total are reservoirized in clastic rocks, 35.0% in carbonates. 95.7% of the total are entrapped in structural and combination traps

Passive margin and foreland basins contain the bulk of the deep petroleum reserves in the world

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Conclusion 2

Stratigraphically, the deep petroleum reserves are largely confined to five reservoir intervals: Neogene (hosting 22.3% of the total), Upper Paleozoic (22.2%), Cretaceous (18.4%), Paleogene (12.8%) and Jurassic (12.8%)

Salt-bearing deep sedimentary basins are significantly more prospective for deep petroleum than basins without salt

We suggest that the deep petroleum exploration should target the play fairways where substantial shallow-intermediate petroleum reserves have already been discovered, particularly those fairways with significant development of salts

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