

Chapter R7

REGION 7 ASSESSMENT SUMMARY—SUB-SAHARAN
AFRICA AND ANTARCTICA

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INTRODUCTION

Region 7, Sub-Saharan Africa and Antarctica, includes most of the continent of Africa, except for the Saharan basins of north Africa ([R7 country map](#)) which are included in Region 2 ([R2](#)). The region also includes the entire continent of Antarctica. For the present assessment, five of the geologic provinces in the region were assessed ([R7 province map](#)).

All of the provinces assessed in this region are along the western Atlantic margin of Africa. Oil and gas fields have been discovered in other areas along the margins of the continent and in interior rift systems, but those provinces were not assessed at this time. Areas to be assessed were chosen either because they probably will be major contributors to world petroleum supply in the next 30 years, or because of the current high interest in the Atlantic marginal basins. The nonassessed areas include the Chad (7066) and Sud (7146) provinces of central Africa, the Mozambique Coastal Province (7343) of southeast Africa, and the South African Coastal Province (7363). Also not assessed were potential coalbed gas resources of the Karoo Province (7355) of onshore South Africa.

None of the continent of Antarctica was assessed. Political, technologic, and economic factors would make only very large discoveries economically feasible to produce. Considering the 30-year limit used in the assessment, we decided not to provide a quantitative assessment at this time.

GEOLOGY OF ATLANTIC DIVERGENT MARGIN

All of the assessments for Region 7 were in provinces of the Atlantic margin. These provinces are mostly bounded landward by Precambrian shields. The seaward province boundaries are either at 2000 m water depth or, in the areas of the Niger and Congo deltas (Niger Delta Province and West-Central Coastal Province) where deep-water turbidites have greater potential, at 4000 m water depth.

Understanding of the geology of both the African and South American margins of the Atlantic, and appreciation of their resource potential, has increased greatly in the last two decades. Some suggested references for general geology of the African Atlantic margin are Brown and others (1995), Cameron and others (1999), Doust and Omatsola (1990), Teisserenc and Villemin (1990), and Uchupi (1989).

The Atlantic Ocean began to open and split the supercontinent of Gondwanaland in the early Mesozoic (Uchupi, 1989). The North Atlantic opened first, from north to south. Initial rifting in the North Atlantic occurred in Late Triassic, followed by the beginning of seafloor spreading in the Middle Jurassic. The South Atlantic opened later, from south to north. Initial rifting in the South Atlantic occurred in the Early Jurassic. Seafloor spreading began in the southern part of the South Atlantic in the Aptian and the northern part of the South Atlantic in the Albian. The area now occupied by the Gulf of Guinea opened last, forming a continuous Atlantic Ocean in the Turonian.

The divergent margin basins along the Atlantic margin began as asymmetric rift basins, filled with nonmarine clastics and volcanics. Organic-rich, rift-stage

lacustrine rocks are some of the most important source rocks in these basins. Salt was deposited in some basins, especially in those of the West-Central Coastal Province during the Aptian, at the south end of which the Walvis Ridge provided a sill, restricting circulation from open marine conditions to the south. Large carbonate platforms developed, especially during the Albian in offshore Congo (Brazzaville) and northern Angola (West-Central Coastal Province). Post-Albian through Recent sedimentation was dominated by several Tertiary deltas, especially those of the Niger and Congo Rivers (Niger Delta Province and West-Central Coastal Province). Marine source rocks of deeper water origin were deposited in the Late Cretaceous (particularly in the Cenomanian and Turonian) and Tertiary.

Many trapping structures in the West-Central Coastal Province are the result of salt movement. In the large delta systems, the trapping structures are commonly down-to-basin growth faults and rollovers. In the Gulf of Guinea Province, the structural regime is complicated by a shear component that created a series of basins and ridges.

Most reservoirs are sandstones. The Albian carbonate reservoirs of the West-Central Coastal Province are the main exception. Turbidites are the reservoirs in many of the most important post-1994 deep-water discoveries. Both channel deposits and basin-floor fans are prospective. This is similar to what has been found, and what is predicted, along the Atlantic margin of South America (R6).

RESULTS

Estimates of undiscovered resources for the assessed portions of Region 7 are summarized in [table R7-1](#). The estimates of undiscovered resources are

particularly high in the areas of the Niger Delta (in the Niger Delta Province, 7192) and the Congo Delta (in the West-Central Coastal Province, 7203). This is evident in high estimates for the shallower-water assessment units (AUs) 71920101 and 72030301 and especially the deeper-water AUs 71920102 and 72030302. In contrast, the Ogooue Delta (part of AU 72030201), offshore Gabon, is expected to be somewhat less rich because it is a smaller Cretaceous delta, rather than a large Tertiary one.

The presence of large deltas is seemingly the factor that most controls the differences in resource richness among the basins in Region 7. Large deltas provide good sandstone reservoirs, not only in the paralic facies, but also in turbidites basinward. Growth faults provide good trapping configurations for the paralic sandstones. The deltas also bury the source rocks deeper, enhancing petroleum generation. Young deltas, where petroleum fluids are currently being generated and are migrating, are expected to be richer because their traps will have had less time to leak or be destroyed.

Other areas with less delta development have smaller estimates. The Senegal Province (AU 70130101), the Gulf of Guinea Province (AU 71830101), and the Cuanza Basin (AU 72030401) of the West-Central Coastal Province have relatively little delta development. The Orange River Coastal Province (AU 73030101) has moderate deltaic development, but here less restricted marine conditions south of the Walvis Ridge were thought to be less suitable for the deposition of good marine source rocks than to the north.

The Central Congo Turbidites AU (72030302) was treated differently for this assessment than most other AUs. Other assessments were conducted using data as

of the end of 1995; fields found later were treated as undiscovered. In most areas, the few small discoveries between the end of 1995 and the time of assessment were not very significant. In the case of [AU 72030302](#), however, almost all of the fields, including several very large ones, were found after 1995. Because of the significance of and great interest in the evolving deep-water plays of offshore Africa, the assessment treated these fields as discovered.

SIGNIFICANCE

The previous USGS world petroleum assessment was documented in Masters and others (1994, 1997). [Table R7-2](#) compares these estimates to the current (2000) assessment for selected countries. Comparisons with the 1994 estimates are not completely relevant because very different areas were assessed. In addition, the deep-water turbidite plays were not as well understood at the time of the previous assessment as they are now. The large deep-water discoveries date from 1995 or later, resulting in the higher estimates for these areas in the current (2000) assessment.

The only estimates shown in [table R7-2](#) that are lower in the current assessment compared to the previous assessment are those for gas in Nigeria. The 2000 estimates for oil, gas, plus NGL in Nigeria are higher than those from 1994 in terms of equivalent barrels, 63.7 BBOE versus 38.2 BBOE. In the 2000 assessment, however, the gas is expected to be a smaller portion of the equivalent energy, 32 versus 76 percent.

More than 75 percent of the undiscovered oil and 73 percent of the undiscovered gas for the assessed areas of Region 7 is expected to be offshore. This compares to

world averages of 47 and 53 percent, respectively. More than 90 percent of the assessed onshore undiscovered oil and gas for Region 7 is expected to be concentrated in the Niger Delta Province. Some of the offshore undiscovered resource is expected to be in water depths greater than current production technology has reached (about 2000 m water depth). Significant resources are expected in water between 2000 m and 4000 m deep in some areas of turbidite reservoirs, especially offshore Angola.

When combined with the substantial undiscovered resource estimated for the geologically related Atlantic margin of South America, the possibility of an emerging major energy-producing region in the South Atlantic is apparent. The resources of this combined region would be primarily from offshore fields, many in deepwater. This could lead to a significant strategic change in the intercontinental import-export flow of petroleum.

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**Table R7-1. Sub-Saharan Africa and Antarctica, Region 7
Assessment Results Summary**

[MMBO, million barrels of oil. BCFG, billion cubic feet of gas. MMBNGL, million barrels of natural gas liquids. Prob., probability (including both geologic and accessibility probabilities) of at least one field equal to or greater than the minimum assessed field size. Results shown are fully risked estimates. For gas fields, all liquids are included under the NGL (natural gas liquids) category. F95 represents a 95 percent chance of at least the amount tabulated. Other fractiles are defined similarly. Fractiles are additive under the assumption of perfect positive correlation. Shading indicates not applicable]

Code and Field Type	Prob. (0-1)	Undiscovered Resources											
		Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
		F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
7		Total: Sub-Saharan Africa and Antarctica											
Oil Fields	1.00	26,783	68,999	124,447	71,512	47,393	130,775	268,891	140,685	1,763	5,180	11,533	5,722
Gas Fields						36,081	89,369	170,545	94,604	2,015	4,762	9,031	5,044
Total	1.00	26,783	68,999	124,447	71,512	83,474	220,144	439,436	235,290	3,778	9,942	20,564	10,766

Table R7-2. Comparison of USGS Assessments of Mean Undiscovered Resources for Selected Countries of Sub-Saharan Africa

	Mean Oil (BBO)		Mean Gas (TCFG)		Mean NGL (BBNGL)	
	Masters	This Report	Masters	This Report	Masters	This Report
Angola	1.9	14.5	4.8	42.7	0.1	2.0
Congo (Brazzaville)	0.4	5.8	3.2	17.4	<0.05	0.8
Gabon	1.7	8.2	1.2	24.3	<0.05	1.2
Nigeria	6.5	37.6	174.4	123.2	2.6	5.6

Masters refers to the estimates in Masters and others (1994, 1997).