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National and Global Petroleum Assessment

Assessment of Conventional Oil Resources of the East African Rift Province, East Africa, 2016

Using a geology-based assessment methodology, the U.S. Geological Survey estimated undiscovered, technically recoverable mean conventional resources of 13.4 billion barrels of oil and 4.6 trillion cubic feet of gas in the East African Rift Province of east Africa.

Introduction

The U.S. Geological Survey (USGS) recently completed an assessment of undiscovered, technically recoverable conventional oil resources within the East African Rift Province (fig. 1), a geologically complex region of approximately 2,916,160 square kilometers in east Africa. The rifts are commonly described as forming an "Eastern Branch" and a "Western Branch." The East African Rift System (EARS) developed in the late Oligocene in the Afar region of Ethiopia shortly after an Eocene–Oligocene flood basalt event in the Lake Turkana and South Lokichar Basin area in the Eastern Branch of EARS (fig. 1) where extensional faults developed within the Precambrian craton. During the middle to late Miocene, rifts developed between Ethiopia and Mozambique in the Western Branch of the EARS within the Precambrian craton (fig. 1) (Davison and others, 2014; Abeinomugisha, 2015). As much as 5,000 meters of Oligocene-to-Holocene sedimentary rocks are present in the rift basins of the province. At the time of this assessment, the province contained 30 oil fields in the rift basins—18 in Uganda and 12 in Kenya—and the province is considered underexplored (IHS Markit™, 2015).

Total Petroleum System and Assessment Units

The East African Rift Province was assessed because of its potential for undiscovered oil resources. The assessment was geology-based and used the total petroleum system (TPS) concept. The geologic elements of a TPS include hydrocarbon source rocks (source rock maturation and hydrocarbon generation and migration), reservoir rocks (quality and distribution), and traps for hydrocarbon accumulation. Using these geologic criteria, the USGS defined the Oligocene–Pleistocene TPS with four assessment units (AUs): the Albertine Graben AU, Tanganyika-Rukwa AU, Lake Malawi AU, and Eastern Arm Rift Basins AU (fig. 1). The AUs include parts of Burundi, Democratic Republic of the Congo, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, South Sudan, Tanzania, Uganda, and Zambia (fig. 1). The TPS was defined to include (1) Oligocene-to-Pleistocene lacustrine source rocks with total organic content ranging from 1 to 17 weight percent; (2) porosity values ranging from 15 to 30 percent in Oligocene-to-Pleistocene clastic reservoirs; (3) permeability values ranging from 50 millidarcies to several darcies; (4) shale seals; and (5) traps that are primarily structural with extensional faulting and minor inversion, although some stratigraphic traps are also present. Oil generation and migration began in the Miocene and most likely continues today (Talbot and others, 2004; Curd and others, 2013).

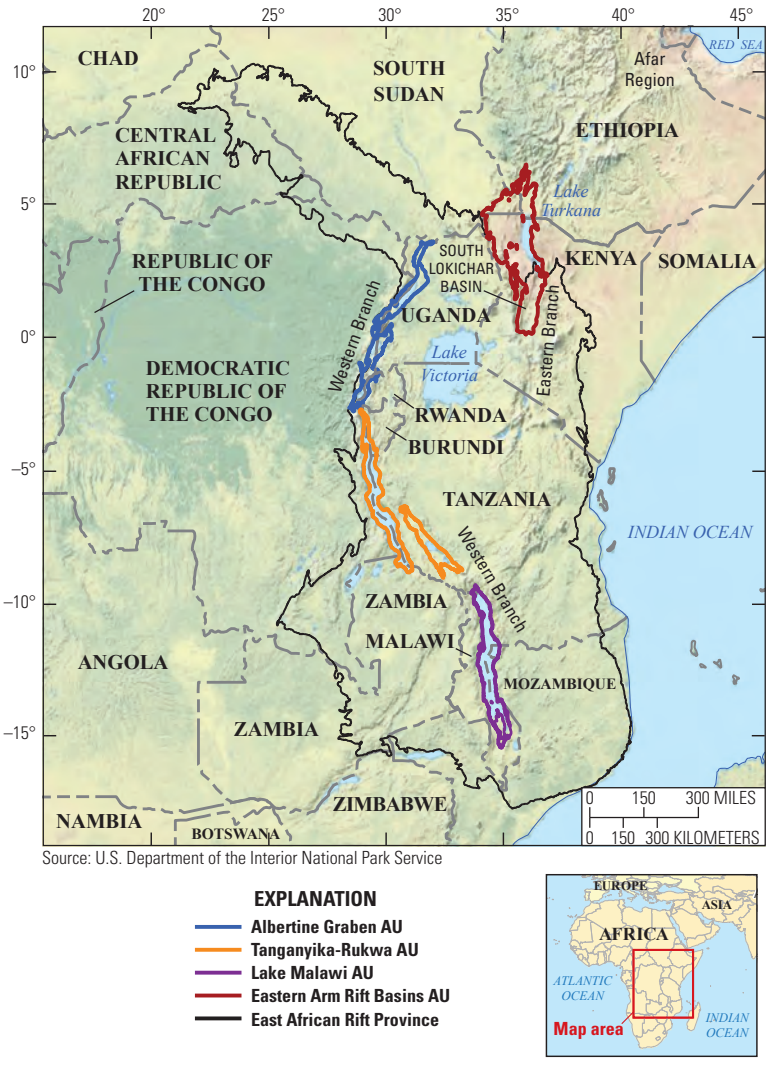

Figure 1. Location of the East African Rift Province and the four assessment units (AUs) defined in this study.

For this assessment, we used a minimum undiscovered field size of 5 million barrels of oil (MMBO). In the Uganda part of the Albertine Graben AU, 15 oil fields are equal to or greater than minimum assessment field size, and in the Kenya part of the Eastern Arm Rift Basins AU, 8 fields equal to or greater than the minimum assessment field size have been discovered (IHS Markit™, 2015). No fields have been discovered in the other AUs. Assessment input data for the four conventional assessment units in the East African Rift Province are shown in table 1. Numbers and sizes of undiscovered oil accumulations are guided by data from geologic analogs.

Undiscovered Resources Summary

The USGS quantitatively assessed undiscovered, technically recoverable conventional oil resources within four assessment units in the East African Rift Province (table 2). The estimated total mean resources are 13,438 million barrels of oil (MMBO), or 13.4 billion barrels of oil, with an F95–F5 range from 4,808 to 25,373 MMBO; 4,648 billion cubic feet of gas (BCFG), or 4.6 trillion cubic feet of gas, with an F95–F5 range from 1,674 to 9,072 BCFG; and 24 million barrels of natural gas liquids (MMBNGL) with an F95–F5 range from 9 to 46 MMBNGL. For oil and gas accumulations, zeros at F95 reflect the chance that oil and gas might not exist in the AU, and the geologic AU probability (risk) was estimated to be less than one.

For the Albertine Graben AU, the estimated mean resources are 1,594 MMBO with an F95–F5 range from 560 to 3,251 MMBO, 435 BCFG with an F95–F5 range from 136 to 964 BCFG, and 2 MMBNGL with an F95–F5 range from 1 to 5 MMBNGL. For the Tanganyika-Rukwa AU, the estimated mean resources are 3,218 MMBO with an F95–F5 range from 1,284 to 6,042 MMBO, 880 BCFG with an F95–F5 range from 320 to 1,780 BCFG, and 5 MMBNGL with an F95–F5 range from 2 to 9 MMBNGL. For the Lake Malawi AU, the estimated mean resources are 1,937 MMBO with an F95–F5 range from 0 to 4,114 MMBO, 529 BCFG with an F95–F5 range from 0 to 1,224 BCFG, and 3 MMBNGL with an F95–F5 range from 0 to 6 MMBNGL. For the Eastern Arm Rift Basins AU, the estimated mean resources are 6,689 MMBO with an F95–F5 range from 2,964 to 11,966 MMBO, 2,804 BCFG with an F95–F5 range from 1,218 to 5,104 BCFG, and 14 MMBNGL with an F95–F5 range from 6 to 26 MMBNGL.

Table 1. Key assessment input data for four conventional assessment units in the East African Rift Province, east Africa.

[AU, assessment unit; MMBO, million barrels of oil. Shading indicates not applicable]

Assessment input data	Albertine Graben AU				Tanganyika-Rukwa AU			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	45	130	47	1	90	270	95
Sizes of oil fields (MMBO)	5	10	2,000	33	5	10	2,000	33
AU probability	1.0				1.0			
Assessment input data	**Lake Malawi AU**				**Eastern Arm Rift Basins AU**			
	Minimum	Median	Maximum	Calculated mean	Minimum	Median	Maximum	Calculated mean
Number of oil fields	1	60	180	63	1	160	450	168
Sizes of oil fields (MMBO)	5	10	2,000	33	5	10	2,800	40
AU probability	0.9				1.0			

Table 2. Assessment results for four conventional assessment units in the East African Rift Province, east Africa.

[Expected largest mean field size in MMBO. MMBO, million barrels of oil; BCFG, billion cubic feet of gas; MMBNGL, million barrels of natural gas liquids. Results shown are fully risked estimates. 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]

Total petroleum system and assessment units (AUs)	AU probability	Accumulation type	Expected largest mean field size	Total undiscovered resources											
				Oil (MMBO)				Gas (BCFG)				NGL (MMBNGL)			
				F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Oligocene–Pleistocene Total Petroleum System															
Albertine Graben AU	1.0	Oil	449	560	1,416	3,251	1,594	136	365	964	435	1	2	5	2
Tanganyika-Rukwa AU	1.0	Oil	635	1,284	2,951	6,042	3,218	320	778	1,780	880	2	4	9	5
Lake Malawi AU	0.9	Oil	523	0	1,809	4,114	1,937	0	467	1,224	529	0	2	6	3
Eastern Arm Rift Basins AU	1.0	Oil	1,098	2,964	6,234	11,966	6,689	1,218	2,599	5,104	2,804	6	13	26	14
Total undiscovered conventional resources				**4,808**	**12,410**	**25,373**	**13,438**	**1,674**	**4,209**	**9,072**	**4,648**	**9**	**21**	**46**	**24**

References Cited

Abeinomugisha, Dozith, 2015, Hydrocarbon exploration in the Albertine Graben of the East African Rift System, *in* East African Rift System Planning Workshop, Morristown, New Jersey, October 25–27, 2012, Proceedings: GeoPRISMS (Geodynamic Processes at Rifting and Subducting Margins), 19 p., accessed January 30, 2017, at http://geoprisms.org/wp-content/uploads/2015/02/019_EARS2012_Dozith.pdf.

Curd, S.R., Downie, R., Logan, P.C., and Holley, P., 2013, The Kingfisher Field, Uganda—A bird in the hand! [abs.], *in* SAMPLE (South Atlantic Margin Processes and Links with Onshore Evolution) Colloquium 2013, Heidelberg, Germany, June 11–14, 2013, Proceedings: South Atlantic Margin Processes and Links with Onshore Evolution, 16 p., accessed December 15, 2016, at http://www.sample-spp.de/internal/london/Posters_Strat%20Studies,%20Reservoirs%20and%20Reserves/Downie_The%20Kingfisher%20Field,%20Uganda%20-%20A%20Bird%20in%20the%20Hand.pdf.

Davison, Ian; Steel, Ian; Taylor, Matthew; Beirne, E.O.; and Faull, Theodore, 2014, Exploration in the East African Rift System: GeoExPro, v. 11, no. 5, p. 26–32.

IHS Markit™, 2015, International petroleum exploration and production database [current through 2015]: IHS Markit, 15 Inverness Way East, Englewood, CO 80112.

Talbot, M.R., Morley, C.K, Tiercelin, J.-J., Le Hérissé, A., Potdevin, J.-L., and Le Gall, B., 2004, Hydrocarbon potential of the Meso–Cenozoic Turkana Depression, northern Kenya. II. Source rocks—Quality, maturation, depositional environments and structural control: Marine and Petroleum Geology, v. 21, no. 1, p. 63–78.

For More Information

Assessment results also are available at the USGS Energy Resources Program website at http://energy.usgs.gov.

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ISSN 2327-6916 (print) ISSN 2327-6932 (online) https://doi.org/10.3133/fs20173006