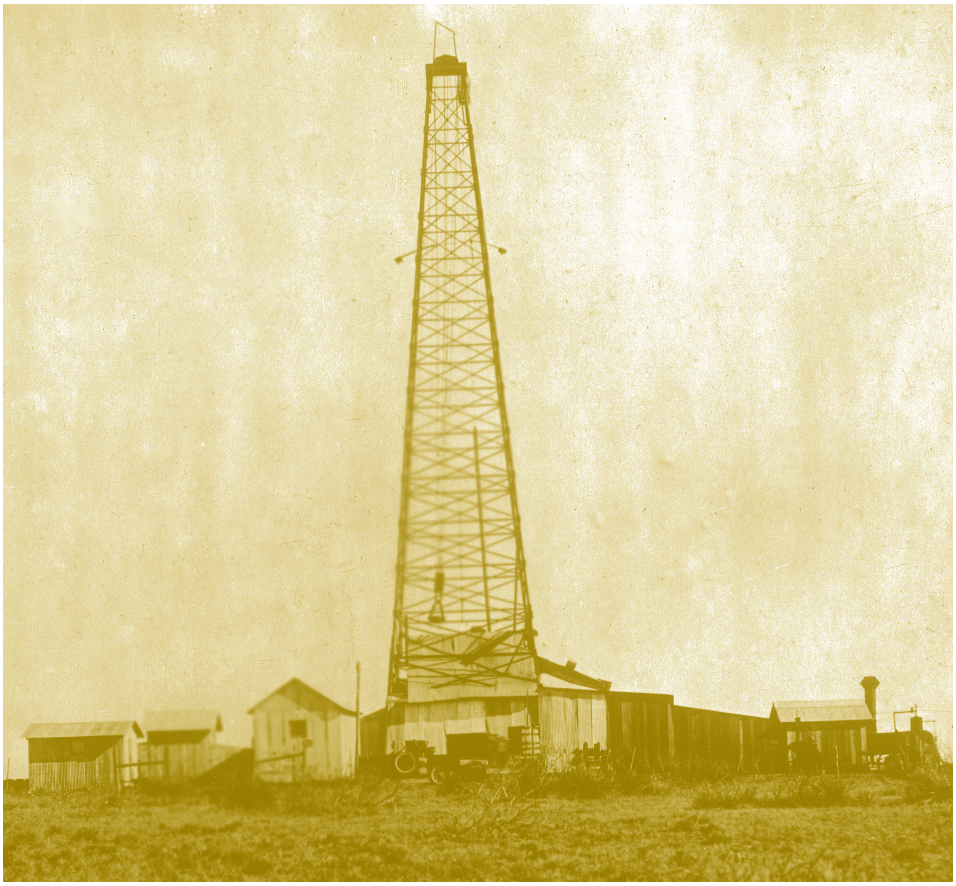
Reserve Growth Assessment Fact Sheet

Assessment of Remaining Recoverable Oil in Selected Major Oil Fields of the Permian Basin, Texas and New Mexico

The U.S. Geological Survey (USGS) recently completed an estimate of technically recoverable, conventional oil in selected oil fields in the Permian Basin in west Texas and southeastern New Mexico. The mean total volume of potential additional oil resources that might be added using improved oil-recovery technologies was estimated to be about 2.7 billion barrels of oil.



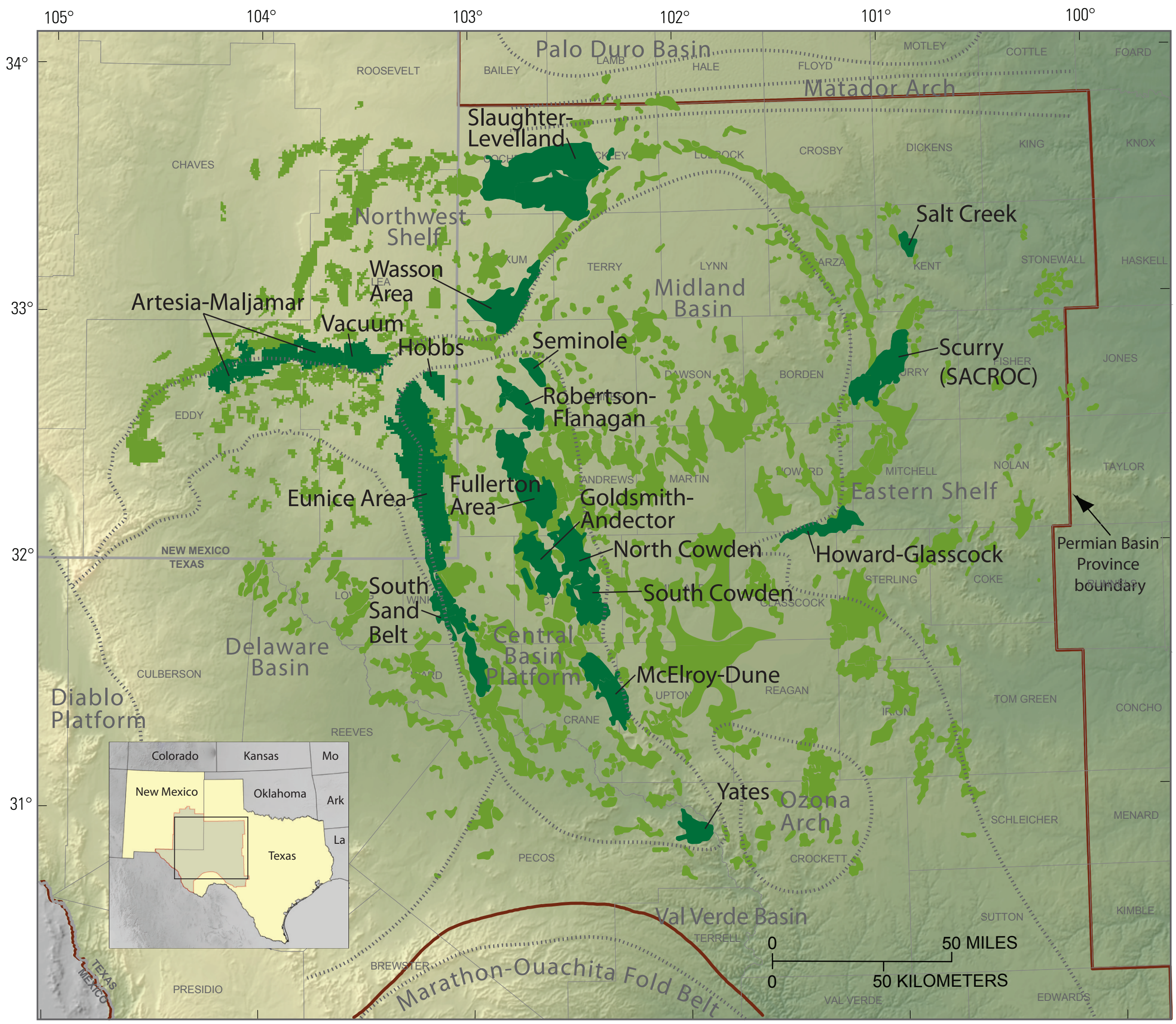
The Permian Basin in west Texas and southeastern New Mexico includes some of the largest oil fields in the conterminous United States. U.S. Geological Survey scientists recently completed an assessment of the potential for additions to oil reserves that could result from applying improved oil-recovery technologies in 18 large oil fields in the basin that were discovered between 1923 and 1950. This photograph taken in 1923 shows the Newnham well (Farmers Oil Company) in Odessa, Texas (U.S. Geological Survey photograph by W.B. Lang).

Introduction

A team of U.S. Geological Survey (USGS) scientists recently completed an assessment of the potential for additions to oil reserves that could result from applying improved oil-recovery technologies in 18 large oil fields in the Permian Basin in west Texas and southeastern New Mexico. During the Paleozoic Era (542 to 251 million years ago), the region was an extensive complex of carbonate shelves and platforms (areas where shallow-marine limestones were deposited), separated by intervening basins, that lay along the southern margin of North America. These include the Northwest Shelf, Central Basin Platform, and Eastern Shelf and the Delaware and Midland Basins.

The oil fields analyzed in this study include some of the larger fields in the conterminous United States and were discovered between 1923 and 1950. Individual estimates of recoverable oil volumes in the 18 fields range from about 430 million barrels of oil (MMBO) to 3 billion barrels of oil (BBO) as of 2006. Estimates of volumes of original oil in place (OOIP) in individual fields range from about 700 MMBO to more than 5 BBO. Between 1979 and 2004, estimates of the volume of recoverable oil in these 18 fields increased by 4.7 BBO (from data in Nehring, 2007).

The principal oil reservoirs in the Permian Basin are carbonate shelf and platform strata with variable porosity and generally low permeability. Primary recovery efficiencies were low, typically 10 to 20 percent of the OOIP. Beginning in about 1950, waterfloods (water injected into reservoirs to force oil out) were increasingly used to improve oil recovery. Starting in about 1970, carbon dioxide (CO_2) injection began to be used in some larger fields to increase oil recovery. Recovery efficiency has reached 50 to 60 percent in a few fields with extensive CO_2 injection, particularly in reservoirs within the Permian (299 to 251 million years ago) San Andres Limestone on the Northwest



Map showing oil fields (green) in the Permian Basin of west Texas and southeastern New Mexico. Oil fields individually assessed are shown in darker green and labeled. Most of the assessed oil fields are composites, consisting of aggregated fields and reservoirs, indicated on the map by hyphenated field names or by the term “Area.” Compiled from maps of individual oil plays in Dutton and others (2004); gray hachured lines are paleogeographic shelf and basin boundaries. SACROC, Scurry Area Canyon Reef Operators Committee.

Shelf and Central Basin Platform and in reef limestones of the Pennsylvanian (318 to 299 million years ago) Canyon Group in the Midland Basin. Because the supply of CO_2 for injection is limited and injection adds substantial expense to operators’ costs, operators of many of the fields studied have only used waterfloods to increase recovery, and the fields therefore still have relatively low recovery efficiencies. In addition, many less-exploited reservoirs have less ideal reservoir properties than those in which advanced recovery technologies have been used. The USGS assessment estimates the range of additional volumes of oil reserves that could be added within the 18 fields analyzed by using CO_2 injection or other advanced oil-recovery technologies. The analysis was made without regard to cost or to availability of CO_2.

Recently, CO_2 injection has begun in several fields within a zone of low oil saturation below the main reservoir interval, called the “residual oil zone.” These efforts have met with some success, but because detailed data with which to evaluate them are not yet available, the USGS analysis did not consider potential reserve additions from the residual oil zone. It is possible that such additions could be substantial.

Methodology

Of the 18 oil fields (or composites of related fields) in the Permian Basin evaluated by the USGS, most exhibited significant additions to reserves from 1982 to 2006. Production and reserves information, as of 2006, came from a proprietary commercial database. To assess the potential for future additions to reserves, an evaluation was made of each field (Klett and others, 2011). The geology of each field was analyzed, and its

Key assessment data for oil fields individually assessed within the Permian Basin, west Texas and southeastern New Mexico.

[MMBO, million barrels of oil (BBO, billion barrels of oil; 1 BBO=1,000 MMBO). Estimated recovery efficiency is potentially recoverable proportion of original oil in place. SACROC, Scurry Area Canyon Reef Operators Committee]

Field	Components (reservoir names in parentheses)	Known recoverable oil (2004)[1] (MMBO)	Estimated original oil in place (MMBO)			Estimated recovery efficiency (percent)		
			min	median	max	min	mode	max
Artesia-Maljamar	Artesia, Loco Hills, Grayburg-Jackson, Maljamar, Pearsall (Queen, Grayburg, San Andres, Glorieta reservoirs)	466	1,000	1,200	1,800	45	50	55
Eunice Area	Eunice-Monument, S. Eunice, N. Monument, Eumont, Fowler, Jalmat, Justis, Langlie-Mattix, Oil Center, Teague, Weir (all reservoirs)	1,005	4,200	4,500	5,000	35	40	45
Fullerton Area	Fullerton, E. Fullerton (San Andres, Clear Fork, Wolfcamp, Ellenburger reservoirs); University Block 13 (Wolfcamp, Devonian, Ellenburger reservoirs)	526	1,500	1,600	2,000	33	36	40
Goldsmith-Andector	Goldsmith, Lawson, Andector (all reservoirs); TXL (upper Clear Fork reservoir)	1,005	1,850	2,100	2,600	40	45	50
Hobbs	Hobbs, Bowers, (all reservoirs)	473	800	1,000	1,300	50	55	60
Howard-Glasscock	Howard Glasscock (Yates, Seven Rivers, Queen, Grayburg, San Andres reservoirs)	509	1,500	1,600	1,800	35	38	50
McElroy-Dune	McElroy, Dune (Grayburg, San Andres, Wolfcamp, Bend 8960, Devonian reservoirs)	876	3,300	3,600	4,000	25	33	40
North Cowden	North Cowden (Grayburg, San Andres, Holt, Canyon, Strawn reservoirs); Venteam (Wolfcamp, Strawn, Ellenburger reservoirs)	758	1,400	1,600	2,100	48	50	60
Robertson-Flanagan	Robertson N, Robertson, North Riley, Harris, Flanagan (Clear Fork, Canyon, Devonian, Ellenburger reservoirs)	560	1,500	1,600	2,000	30	35	40
Salt Creek	Salt Creek (Canyon reservoir)	416	680	700	730	60	63	65
Scurry (SACROC)	Kelly-Snyder, Diamond-M, North Snyder, (San Andres, Clear Fork, Wichita-Albany, Wolfcamp, Cisco Sand, Canyon, Strawn reservoirs)	1,735	3,000	3,100	3,300	55	62	65
Seminole	Seminole (San Andres, San Angelo, Wolfcamp, Devonian reservoirs)	784	1,250	1,300	1,400	55	60	65
Slaughter-Levelland	Slaughter, Levelland, Dean, Rhodes (San Andres, Clear Fork, Wichita-Albany, Abo, Strawn reservoirs)	2,380	4,200	4,600	5,600	48	50	60
South Cowden	Cowden, South Cowden, Foster, Johnson (Grayburg, San Andres, Glorieta, Cisco, Canyon, Devonian, Ellenburger reservoirs)	656	2,100	2,200	3,000	30	35	40
South Sand Belt	North Ward Estes, Scarborough, Hendrick, Kermit, Halley, Emperor, H.S.A, Weiner (Yates, Seven Rivers, Queen, Grayburg, Holt, Glorieta, Clear Fork, Wichita-Albany, Wolfcamp, Canyon, Thirtyone, Fusselman, Montoya, Simpson, McKee, Ellenburger reservoirs)	990	2,900	3,000	3,500	35	40	45
Vacuum	Vacuum; N. and Middle Vacuum (Yates, Grayburg-San Andres, Glorieta, Brinebry, Drinkard, Bone Spring, Abo, Wolfcamp, Cisco, Canyon, Atoka, Wristen reservoirs)	745	1,600	1,800	2,100	45	50	55
Wasson Area	Wasson, Ownby, Russell (San Andres, Glorieta reservoirs)	2,647	4,410	4,500	4,600	58	60	63
	Wasson 66, Wasson 72, Wasson E., S., S.E., and N.E. (Clear Fork and older reservoirs)	293	900	1,000	1,200	27	33	45
Yates	Yates, Toborg (Artesia, Grayburg, San Andres reservoirs)	1,775	4,000	4,300	5,000	40	45	55

[1] Nehring (2007); 2004 values are shown because 2006 values are proprietary.

development history reviewed. Estimates of OOIP in each field were made using information available from various published and proprietary sources. Potential growth was evaluated by estimating the range of recovery efficiency that might be realized with further application and refinement of existing technologies, regardless of economic factors or availability of CO_2.

Results

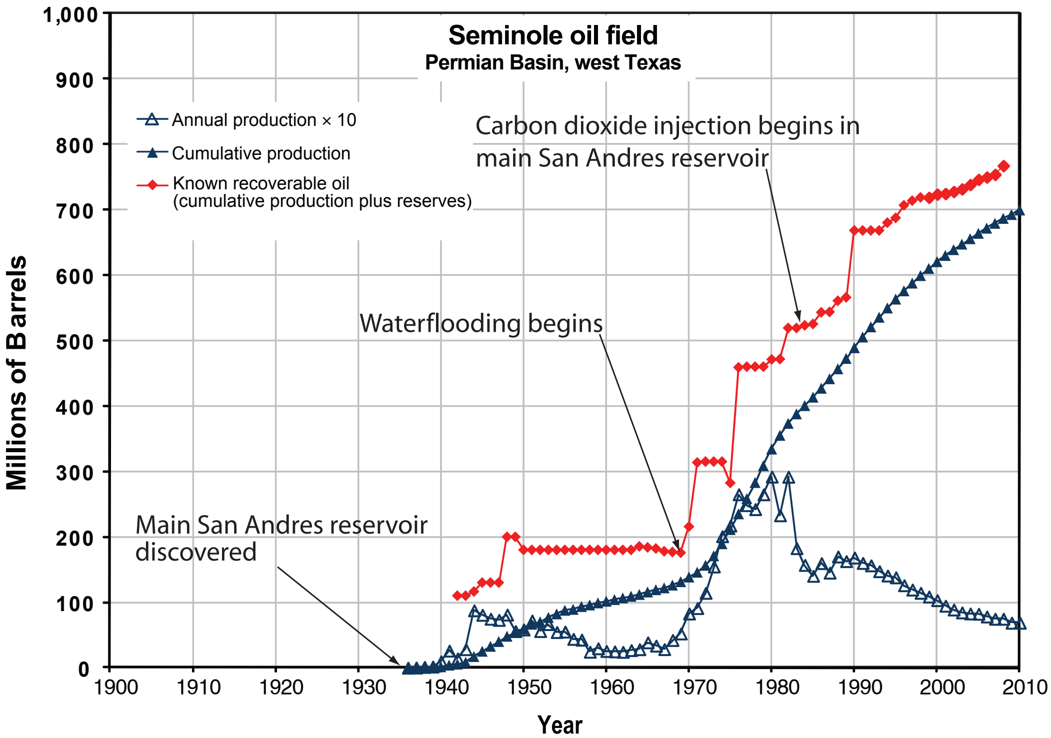
The USGS analysis indicates that there is significant remaining potential for additions to oil reserves in the 18 Permian Basin oil fields evaluated. The largest reservoirs—the San Andres, Grayburg, and Canyon—have contributed the most to growth to oil reserves in recent decades and have already achieved high recovery efficiencies with the extensive use of waterflood and CO_2 recovery programs. Reserves within them are not likely to grow as much in most of the fields as within less intensively developed, deeper reservoirs, but the magnitude of additions may be less than in the past because reservoir character in the deeper reservoirs is poorer. The mean USGS estimate is that an additional 2.68 BBO could be added to reserves in the 18 fields evaluated. There is little chance that reserve additions could be more than 4.5 BBO or less than 1.05 BBO. These volumes may not be currently economic to recover and will require a significantly greater supply of CO_2 for injection than is presently available.

Oil reserves will also continue to be added in fields within the Permian Basin that were not included in this analysis. Most such fields are smaller than the fields studied, and their additions to reserves will also be smaller, although they may be significant. Statistical methods, like those used in previous USGS reserve growth estimates, are being used to approximate a volume of additional reserves that might be expected to come from these smaller fields.

References Cited

Dutton, S.P., Kim, E.M., Broadhead, R.F., Breton, C.L., Raatz, W.D., Ruppel, S.C., and Kerans, C., 2004, Play analysis and digital portfolio of major oil reservoirs in the Permian Basin—Application and transfer of advanced geological and engineering technologies for incremental production opportunities, final report: Austin, Texas, Bureau of Economic Geology, and Socorro, New Mexico, New Mexico Institute of Mining and Technology, accessed March 8, 2012, at http://www.beg.utexas.edu/resprog/permianbasin/playanalysis.htm.

Klett, T.R., Attanasi, E.D., Charpentier, R.R., Cook, T.A., Freeman, P.S.,



The history of Seminole oil field on the Central Basin Platform in west Texas is typical of many fields in the Permian Basin. By 2010, the field had produced about 700 million barrels of oil (MMBO), mostly from carbonate reservoirs of the Permian San Andres Formation. Before waterflooding began in the late 1960s, production was declining and the volume of oil expected to be recovered was less than 200 MMBO, about 14 to 17 percent of the approximately 1.2 to 1.4 billion barrels of oil originally in place. With waterflooding, production increased significantly and the volume of recoverable oil grew to more than 500 MMBO. In the early 1980s, carbon dioxide injection began, slowing the decline in production and increasing the recoverable volume to more than 750 MMBO. This study concluded that reserves in this field are not likely to grow much more. (Production and reserves data from Oil and Gas Journal and the Texas Railroad Commission; reserves after 1998 approximated by 10 times annual production. Annual production plotted at 10 times actual value for legibility.)

Gautier, D.L., Le, P.A., Ryder, R.T., Schenk, C.J., Tennyson, M.E., and Verma, M.K., 2011, New U.S. Geological Survey method for the assessment of reserve growth: U.S. Geological Survey Scientific Investigations Report 2011–5163, 8 p., available at http://pubs.usgs.gov/sir/2011/5163/.

Nehring, R. 2007, The oil recovery growth of the Permian Basin, USA: Colorado Springs, Colo., Nehring Associates, accessed March 7, 2012, at http://www.nehringdatabase.com/images/pdfs/Permian%20Growth%20Poster.pdf.

Assessment results for volume of additional oil potentially recoverable from selected oil fields in the Permian Basin, west Texas and southeastern New Mexico (technically recoverable resources).

[Mean estimates add to a total mean, but fractile values for individual fields are not additive; fractiles (non-additive) for the entire group of fields are shown in the bottom row highlighted in yellow. MMBO, million barrels of oil (BBO, billion barrels of oil; 1 BBO=1,000 MMBO). F95 denotes a 95-percent chance of at least the amount tabulated, F50 denotes a 50-percent chance, and F5 denotes a 5-percent chance. Negative values indicate a chance that reserves could decrease from currently estimated values]

Field	Reservoir(s)	Oil (MMBO)			
		F95	F50	F5	Mean
Artesia-Maljamar	All reservoirs	44	132	300	146
Eunice Area	All reservoirs	633	810	1001	812
Fullerton	All reservoirs	–9	41	122	47
Goldsmith-Andector	All reservoirs	27	137	285	144
Hobbs	All reservoirs	–25	59	168	64
Howard-Glasscock	All reservoirs	62	137	248	144
McElroy-Dune	All reservoirs	92	290	489	291
North Cowden	All reservoirs	–33	70	235	81
Robertson-Flanagan	All reservoirs	–11	54	139	58
Salt Creek	All reservoirs	–7	9	25	9
Scurry	All reservoirs	–28	104	218	101
Seminole	All reservoirs	–44	7	61	7
Slaughter-Levelland	All reservoirs	–289	–44	318	–22
South Cowden	All reservoirs	29	117	250	126
South Sand Belt	All reservoirs	61	175	305	179
Vacuum	All reservoirs	68	161	272	164
Wasson Area	Clear Fork and older reservoirs	–10	50	131	54
	San Andres and Glorieta reservoirs	–57	22	114	25
Yates	All reservoirs	4	233	532	247
All evaluated fields	All evaluated reservoirs	1,052	2,611	4,512	2,676

Reserve Growth Assessment Team:
Marilyn E. Tennyson, Troy A. Cook, Ronald R. Charpentier, Donald L. Gautier, Timothy R. Klett, Mahendra K. Verma, Robert T. Ryder, Emil D. Attanasi, Philip A. Freeman, and *Phoung A. Le*

Edited by *James W. Hendley II*
Graphic design by *Steve Scott*

For Further Information

Supporting geologic studies of total petroleum systems and assessment units and reports on the methodology used in this assessment, as well as the assessment results, are available at the USGS Energy Resources Program Web site:
http://energy.usgs.gov/
or contact
Marilyn E. Tennyson (tennyson@usgs.gov)

This Fact Sheet and any updates to it are available online at
http://pubs.usgs.gov/fs/2012/3051/