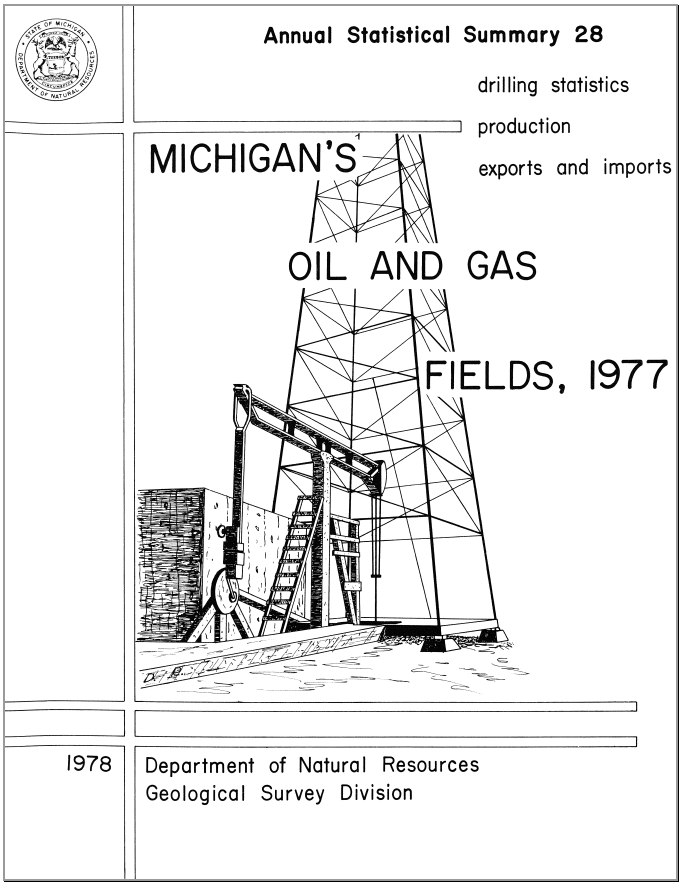

MICHIGAN'S OIL AND GAS FIELDS, 1977

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ACKNOWLEDGEMENTS

The Geological Survey Division's Oil and Gas Section consists of a Regulatory Control Unit, a Production-Proration Unit, and a Subsurface and Petroleum Geology Unit. A Cartographic Subunit is under the management of the Subsurface and Petroleum Geology Unit. Field operations are handled by personnel assigned to field offices within DNR Regions II and III. A Regional Geologist, under the supervision of the Regional Director, guides the overall activities of the several field offices within his region. Field offices are located at Plainwell, Cadillac, Gaylord, Mt. Pleasant, Imlay City, and Lansing. Field activities are mainly those associated with the responsibilities of the Regulatory Control and Production-Proration Units, but do include the gathering of certain year end oil-and-gas field statistics used to a limited extent in this report.

The compilation and assembly of various oil and gas field data into a yearly report is a major responsibility of the Subsurface and Petroleum Geology Unit. Certain data collected by field office personnel are contributed to this report by Unit supervisors who are under the general supervision of R. M. Acker, Assistant State Geologist and Chief of the Oil and Gas Section. Unit supervisors who provided specific information are:

S. L. Alguire, Supervisor, Regulatory Control Unit. Contribution: All data in columns under the headings "Number of Oil and Gas Wells" and "Brine Production" on Tables 2, 3, and 4.

James S. Lorenz, Supervisor, Production-Proration Unit. Contribution: All Michigan oil and gas production data, oil and gas valuation figures, import and export figures, LPG and condensate figures, secondary recovery projects (Table 5), and refineries.

G. D. Ells, Supervisor, and D. M. Bricker and staff, Subsurface and Petroleum Geology Unit. All general drilling statistics and well completion data, discovery well and deep test data, cumulative

records, and all other summary information not specifically provided by other Unit supervisors or by other agencies. Maintenance and compilation of statistics, assembly and manuscript preparation by staff members of the Subsurface and Petroleum Geology Unit: G. D. Ells, D. M. Bricker, R. C. Elowski, A. G. Ostrander, M. A. Morris, Margaret Schineman, Diane Schulte, Anita Welton, and Jane Thomas.

The compilers also acknowledge the assistance of Gas Section personnel, Public Utilities Division, Department of Commerce, in providing figures on natural gas imports via interstate pipelines, and the Lands Division, Department of Natural Resources, in providing figures for state revenue derived from various oil and gas transactions.

Michigan oil and gas production figures maintained by the Production-Proration Unit are compiled by the Unit from records obtained from the Michigan Department of Treasury and from records filed by producers and purchasers. All hydrocarbon production figures cited herein are subject to correction as warranted.

Inquiries concerning information contained in this publication should be directed to the appropriate Unit supervisor as noted earlier.

Compilers: G. D. Ells
D. M. Bricker
R. C. Elowski
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M. A. Morris

Lansing, Michigan
October, 1978

INTRODUCTION

To help foster the development of Michigan's hydrocarbon resources, statistical data have been maintained and published for many years. This issue of the oil and gas field statistical summary brings together information on various facets of Michigan's oil and gas industry activities during 1977. Certain indices which show the trend of these activities from year to year are shown in chart form along with figures from prior years. Other charts reflect cumulative data and other historical information useful in oil and gas field evaluation.

The information contained in the 1977 oil and gas summary has been treated as uniformly as possible from year to year so that the data reflect accurately the actual figures and other information that should be credited to this year. The data found herein are mainly derived from records maintained by the Oil and Gas Section, Geological Survey Division, Department of Natural Resources.

This publication is essentially divided into three parts. The first summarizes significant statistics on oil and gas field activities for 1977 and includes other related records kept by the Oil and Gas Section. Part 2 contains specific information on Michigan's oil and gas fields, gas storage fields, and other related subjects. Part 3 contains cumulative records important to the oil and gas industry. Data for 1977 have been included in these cumulative records.

Certain well completion data are furnished to the American Petroleum Institute (API) and the American Association of Petroleum Geologists (AAPG) on a regular basis. Reports citing preliminary oil and gas statistics and production figures are also prepared for the Interstate Oil Compact Commission (IOCC). API publishes the data in monthly and quarterly reports. Year-end printouts of the data are made available to authors of the AAPG yearly Development Papers and to others. Year-end figures published by API are in general agreement with figures for similar categories published in this summary. Differences which may occur are shown under the appropriate subject heading in this report. Oil and gas production data are supplied by request to the United States Bureau of Mines for publication in their minerals yearbook.

Statistical data on Michigan oil and gas activities, derived from outside sources, are also published by the Oil and Gas News, Mt, Pleasant, Michigan; Petroleum Information, Incorporated, Denver, Colorado; American Petroleum Institute, Washington, D.C.; American Association of Petroleum Geologists, Tulsa, Oklahoma; Interstate Oil Compact Commission, Oklahoma City, Oklahoma; World Oil, Houston, Texas; and Oil and Gas Journal, Tulsa, Oklahoma.

It should be noted that certain figures for the number of exploratory, development, and service wells drilled and completed, the number of new fields and pools discovered, oil and gas production figures, and other data published in this summary may differ from figures reported by regional or national trade publications or by industry reporting services in 1977. The differences in the various statistics are generally minor and are due to methods of gathering and reporting well data, determining cutoff dates for reporting yearly statistics, and the necessity for making projections and estimates for certain types of reports.

Other factors which may result in statistical differences are internal decisions of the Oil and Gas Section regarding final year-end status of completed wells and decisions resulting from public hearings on oil and gas matters. For example, a well originally classified as a development well, and reported as such to one of the above organizations, may later be reclassified as the discovery well for a new pool or field, or a gas well might later be declared an oil well completion on the basis of new evidence. Frequently the changes in well status cannot be readily passed on to these outside organizations so that their records can be updated prior to publication of their final statistics. The discrepancies in year-end figures are almost without exception related to Niagaran reef exploration and development which has

formed the largest part of Michigan drilling activities for the past several years.

PART I
1977 STATISTICAL DATA

* * * OIL AND GAS PERMITS * * *

Oil and gas drilling permits issued under Act 61, P.A. of 1939, as amended, during 1977 began with permit number 31415 and ended with permit number 32106. The total number of permits issued in 1977 was 692 as compared with 645 in 1976. The initial classification of wells to be drilled under these permits was as follows:

INITIAL CLASSIFICATION	1975	1976	1977
Exploratory wells	319	331	338
Development wells	293	253	296
Gas storage facility wells .	37	36	53*
Brine disposal wells . . .	4	25	5
	653	645	692

*Includes 2 LPG storage wells.

The distribution of oil and gas drilling permits according to districts (see oil and gas districts map) through a five year period, including 1977, is as follows:

DRILLING PERMITS BY DISTRICT

DISTRICTS	Permits Issued				
	1973	1974	1975	1976	1977
Basin	120	98	100	110	135
Northern	173	210	219	221	261
Southeastern	67	62	70	98	111
Southwestern	28	44	108	73	67
Western	56	89	156	143	118
Totals	444*	503*	653*	645*	692*

*Includes terminated permits. Permits issued under Act 61, P.A. of 1939, as amended, are terminated one year after date of issue if actual drilling operations have not begun.

Since 1975, permits to drill wells for oil field brine disposal have been issued under the regular permit numbering system rather than under a separate permit numbering system as was done in the past. Deepening permits were issued for 51 wells during 1977 as compared with 47 the previous year. Deepening permits issued in 1977 began with number 1866 and ended with number 1916.

Michigan's oil and gas permit system began in 1927 with the issuance of permit number 1. Since then, permit numbers have been issued in numerically consecutive order. In many cases, wells which have been previously drilled and abandoned have been reopened and reworked under a new permit number. Also, some well locations for which permit numbers were issued but later terminated have been repermitted and assigned new permit numbers. Such multiple permit numbers for the same well location may lead to some confusion. Therefore an attempt is being made to keep a published account of these possible sources of conflict. Terminated permits were listed for the first time in Annual Statistical Summary 16, 1972. Permit number issued for wells drilled under previous permits, or new permit numbers issued for terminated permits, were cited for the first time in Annual Statistical Summary 18, 1973. Permit numbers issued in 1977 for a previously drilled well or for a previously terminated permit are listed in Part 3. Permits issued in 1976 and terminated in 1977 are shown below.

[Permits Terminated in 1977]

Permits issued in 1976 and terminated in 1977

1859*	31135	31268	31390
1860*	31193	31272	31396
31007	31194	31285	31397
31032	31227	31299	31411
31065	31232	31309	31413
31072	31236	31311	31414
31110	31238	31324	
31123	31257	31332	
31124	31260	31349	

*Deepening permits

Directionally drilled holes. Environmental and economic considerations have necessitated the drilling of a large number of directional holes since 1972, particularly to help locate Niagaran reefs. Many of these holes involve using the upper part of a previously drilled hole which, after being initially completed as a dry hole, was plugged back to an appropriate depth and directionally drilled to a more favorable subsurface location. These directionally drilled holes fall in three main categories: 1) a single directional hole completed as either a producer or a dry hole; 2) cases where two or more directional holes have been drilled to separate bottom-hole targets from the same surface location by using the same upper part of the hole; and 3) cases where one or more directional holes have been deviated to new bottom-hole targets after the original vertically drilled test failed to encounter reefing. Only one producing well is allowed per well bore, regardless of the number of holes directionally drilled from the same well bore.

Each new directional hole, even if drilled from the same surface location and using the upper part of a previously drilled test, is treated as a separate test and is assigned its own unique permit number. Each additional hole drilled from the same surface location retains the same well name and number as the original hole, except that the suffix "A", "B", "C", etc., is added to the well number. In some instances, permits for directional holes were terminated and then repermitted under a new number. An attempt has been made to record and publish permit numbers for directionally drilled tests for the benefit of those people who may find the information useful in computer-well data systems. Permit numbers issued for directional holes for 1976 and directional holes with two or more permit numbers are listed in Part 3. Permits issued in 1977 for directional holes are as follows:

Permit numbers issued in 1977 for directional holes

31415	Otsego County	31752	Otsego County
31427	Macomb County	31759	Oakland County
31430	Eaton County	31761	Kalkaska County
31435	Wexford County	31762	Oakland County
31436	Gd. Traverse County	31774	Calhoun County
31437	Gd. Traverse County	31776	Otsego County
31439	Macomb County	31784	Gd. Traverse County
31449	Gd. Traverse County	31785	Mason County
31454	Wexford County	31796	Otsego County
31457	Gd. Traverse County	31798	Otsego County
31460	Gd. Traverse County	31799	Otsego County
31465	Gd. Traverse County	31800	Otsego County
31471	Otsego County	31801	Otsego County
31476	Gd. Traverse County	31803	Wexford County
31481	Manistee County	31816	Kalkaska County
31482	Manistee County	31820	Manistee County
31483	Gd. Traverse County	31822	Manistee County
31489	Manistee County	31823	Kalkaska County
31490	Macomb County	31832	Gd. Traverse County
31503	Calhoun County	31833	Manistee County
31513	Gd. Traverse County	31834	Mason County
31521	Otsego County	31836	Gd. Traverse County
31552	Gd. Traverse County	31848	Macomb County
31554	Gd. Traverse County	31850	Gd. Traverse County
31558	Alpena County	31851	Gd. Traverse County
31559	Gd. Traverse County	31855	Benzie County
31563	Wexford County	31870	Otsego County
31565	Gd. Traverse County	31873	Manistee County
31566	Kalkaska County	31879	Manistee County
31572	Gd. Traverse County	31889	Kalkaska County
31587	Calhoun County	31890	Benzie County
31588	Gd. Traverse County	31894	Manistee County
31591	Gd. Traverse County	31897	Kalkaska County
31599	Kalkaska County	31902	Manistee County
31605	Macomb County	31907	Manistee County
31610	Kalkaska County	31910	Gd. Traverse County
31613	Gd. Traverse County	31925	Kalkaska County
31614	Eaton County	31945	Otsego County
31622	Gd. Traverse County	31948	Gd. Traverse County
31637	Gd. Traverse County	31949	Kalkaska County
31638	Alpena County	31962	Kalkaska County
31641	Gd. Traverse County	31966	Presque Isle County
31642	Manistee County	31971	Manistee County
31643	Gd. Traverse County	31989	Otsego County
31644	Crawford County	31995	Manistee County
31646	Otsego County	31997	Manistee County
31647	Manistee County	32005	Calhoun County
31649	Gd. Traverse County	32006	Manistee County
31650	Macomb County	32008	Otsego County
31656	Kalkaska County	32009	Mason County
31658	Gd. Traverse County	32010	Manistee County
31663	Kalkaska County	32019	Manistee County
31680	Gd. Traverse County	32022	Manistee County
31683	Gd. Traverse County	32032	Otsego County
31693	Kalkaska County	32036	Manistee County
31699	Macomb County	32037	Gd. Traverse County
31700	Macomb County	32059	Manistee County
31702	Kalkaska County	32065	Manistee County
31706	Otsego County	32066	Ingham County
31711	Eaton County	32073	Otsego County
31715	Manistee County	32074	Manistee County
31726	Calhoun County	32086	Gd. Traverse County
31727	Otsego County	32089	Manistee County
31743	Manistee County	32096	Manistee County
31750	Gd. Traverse County	32105	Manistee County

Service well permits. The fluctuation in the number of permits issued to drill gas storage wells and other service well types over a five year period is as follows:

SERVICE WELL PERMITS

Type of Service Well	1973	1974	1975	1976	1977
Gas storage	66	30	37	28	51
LPG, Water Injection	8	11	0	14	2
Brine disposal, etc.	1	1	4	11	5
	75	42	41	53	58

Rework applications, transfers of ownership, etc. In addition to issuance of permits for various types of wells covered under Act No. 61, P.A. of 1939, as amended, 219 applications were received and approved for rework operations on existing wells. Letters of termination were sent out for 33 previously issued permits. Transfers of ownership were processed for 72 wells. Corrections of location, well name, or other detail involving specific permits were made for 50 wells, and cancel and transfer of permit were made for 9 others. The surface location as well as the projected bottom-hole location is published for each permitted directionally drilled hole. After the well is drilled and the directional survey is filed, the correct bottom-hole location is determined from the survey record and then published as a correction for the initial projected bottom-hole location. Corrections of this type were published for 110 wells drilled during 1976 and 1977.

Oil and gas hearings. During 1977, Oil and Gas Section activities also included scheduling and preparation for hearings on oil and gas matters and the issuance of orders resulting from these hearings. These activities are summarized as follows:

Oil Advisory Board Hearings held 9
Causes heard 41
(Includes 3 causes continued, 4 causes dismissed and 2 causes denied and 1 emergency order.)
Spacing Orders issued 35
(Includes 9 amendments to spacing orders)
Abrogation of Spacing Orders 4
Administrative Hearings held 18
Includes: 9 exceptions to spacing orders
1 pressure maintenance project
1 exception to general rule
1 reclassify pool from gas to oil
1 established 2 separate reservoirs and multiple zone completion
1 established 2nd well on 160-acre voluntary unit and established proration
2 unitization orders
Show Cause Hearing 1
Department Environmental Hearing 1
(10 permits issued in Pigeon River)

* * * WELL COMPLETIONS * * *

There were 547 new-hole exploratory and development wells which reached total depth and were considered either completed producers with production casing set, or dry holes during 1977. The 547 wells considered as completed during the past year do not include service wells, old wells drilled to deeper objectives, or reworked wells. Well completion figures for individual counties are shown in Table 1. The fluctuation in the number of new-hole completions and the resulting number of oil, gas, or dry holes over a five year period is as follows:

EXPLORATORY AND DEVELOPMENT WELL COMPLETIONS

Year	Exploratory Wells			Development Wells			Totals
	Oil	Gas	Dry	Oil	Gas	Dry	
1973	38	37	117	43	10	56	301
1974	54	39	173	80	22	62	430
1975	53	17	213	112	21	117	533
1976	30	36	234	90	21	99	510
1977	35	36	230	101	34	111	547

There were 50 new-hole service well completions in 1977. The figure does not include reworked wells or old wells converted to gas storage facility wells. The fluctuation in the number of service well completions over a five year period is as follows:

SERVICE WELL COMPLETIONS

Year	GS	INJ	LPG	BDW	Totals
1973	60	5	2	1	68
1974	38	13	2	1	54
1975	37	0	0	1	38
1976	25	13	0	12	50
1977	43	2	1	4	50

Drilling statistics for Michigan published by API and derived from data supplied by the Geological Survey (G.S.) are shown below, along with figures for the same categories published herein as final year-end figures. API figures have been extracted from the Quarterly Review of Drilling Statistics for the United States, Fourth Quarter, 1977, Annual Summary 1977, American Petroleum Institute, Vol. XI, No. 4, March 1978, Tables I, II, III, and V, pp. 14-22.

API EXPLORATORY AND DEVELOPMENT WELL COMPLETIONS

Year	Exploratory Wells			Development Wells			Totals
	Oil	Gas	Dry	Oil	Gas	Dry	
1977	36	33	260	113	36	117	595
G.S.	35	36	230	101	34	111	547

TOTAL WELLS DRILLED IN MICHIGAN (API)

Year	Oil Wells	Gas Wells	Dry Holes	Service Wells	Total Wells All Types
1977	149	69	377	5	600
G.S.	136	70	341	50*	597

*API does not require information on wells drilled for gas storage. The Geological Survey considers gas storage wells as a class of Service Well. 43 of the 50 Service Wells cited were gas storage facility wells.

NEW-FIELD WILDCAT WELLS DRILLED IN MICHIGAN (API)

Year	Oil	Gas	Total Producing Wells	Dry Holes	Total New-Field Wildcat Wells
1977	35	33	68	258	326
G.S.	35	36	71	230	301

Major and independent company well completions. Requests are frequently made for statistics on major oil company drilling activities in Michigan. The figures cited for the major companies do not include wells drilled by independents under farmout agreements with a major company or wells drilled by independents but partially supported by dry hole money or some other significant assistance from a major oil company. Independent oil companies, who have drilled most of Michigan's wells, are too numerous to cite individually. All figures cited for majors and independents were derived from inspection of operator names appearing on completion records. On the following chart, in cases where two or more companies were joint operators in a drilling venture, the well completion was attributed to the company whose name appears first (generally the major interest holder) on the official records. Although there appears to be no single definition of what constitutes a major company, the following companies are frequently cited as belonging in that category: Atlantic-Richfield, Cities Service, Continental Oil Company, Exxon, Getty Oil Company, Gulf Oil Company, Marathon Oil Company, Mobil Oil Corporation, Phillips Petroleum Company, Shell Oil Company, Standard Oil of California, Standard Oil of Indiana, Standard Oil of Ohio, Sun Oil Company, Texaco, Inc., and Union Oil of California. The preceding list is not official nor necessarily complete. A number of these companies or their affiliates drilled wells in Michigan in 1977.

WELL COMPLETIONS BY MAJORS AND INDEPENDENTS IN 1977

Major Company	Exploratory			Development			Service*	Totals
	Oil	Gas	Dry	Oil	Gas	Dry		
Amoco	6	4	21	7	2	6	0	46
Cities Serv.	0	0	1	0	0	0	0	1
Getty	1	0	5	0	0	1	0	7
Marathon	0	0	2	8	0	0	0	10
Mobil	0	0	1	3	0	1	1	6
Shell	14	14	77	21	12	44	2	184
Union	0	0	0	2	0	0	1	3
Gulf	0	0	2	0	0	0	0	2
Sun	0	0	0	5	0	0	0	5
Sub-totals	21	18	109	46	14	52	4	264
Independents	14	18	121	55	20	59	46	333
Totals	35	36	230	101	34	111	50	597

*Includes GS-OBS, LPGS WI, BDW wells.

Total: Exploratory Wells 301; Development Wells 246; Service Wells 50.

Exploratory Wells drilled by Majors 49%.
Exploratory Wells drilled by Independents 51%.

Exploratory Discoveries made by Majors 55%.
Exploratory Discoveries made by Independents 45%.

Development Wells drilled by Majors 46%.
Development Wells drilled by Independents 54%.

Producing Development Wells drilled by Majors 44%.
Producing Development Wells drilled by Independents 56%.

Discovery to Exploratory Dry Hole Ratio -
Majors 1:2.80; Independents 1:3.78.

Well casing used in 1977 well completions. Periodically, inquiries are made concerning the amount of casing (pipe) used in Michigan wells during a given year. Almost all oil and gas tests drilled in this state utilize

rotary drilling techniques and require the setting of surface pipe and an intermediate casing string. A conductor pipe is set on many holes, and all wells completed as producers require a string of production casing. Pipe size ranges and amounts have been determined from records of wells completed in 1977. For convenience, casing tallies have been related to a range of casing sizes as shown in the following chart.

	Conductor Pipe	Surface Pipe	Intermediate Pipe	Production Pipe
Casing Size Range Used	13"-20" Dia.	10"-13" Dia.	6"-10" Dia.	4-1/2"-6" Dia.
Normal Size Used	16"	11-3/4"	8-5/8"	5-1/2"
Average Weight	75#/ft.	53#/ft.	37#/ft.	19#/ft.
No. feet used (1)	29,746	305,703	1,363,133	1,028,191
Miles (2)	5.63	57.90	258.17	194.73
Tons (3)	1,115.48	8,101.13	25,217.96	9,767.82

(1) Total footage: 2,726,773
(2) Total miles: 516.43
(3) Total tonnage: 62,715.78 based on an average weight for all sizes of 46# per foot.

NEW WELL COMPLETIONS BY DISTRICTS, 1977

Classification of New Well Completions	Basin 1976	Basin 1977	Northern 1976	Northern 1977	Western 1976	Western 1977	Southwestern 1976	Southwestern 1977	Southeastern 1976	Southeastern 1977	Total 1976	Total 1977
Exploratory Wells												
Oil	2	3	17	18	8(2)	10	3	4	0	0	30	35
Gas	3(1)	3	16	18	10	11	3	2	4	2	36	36
D&A	32	25	101	115	45	31	24	23	32	36	234	230
Total	37	31	134	151	63	52	30	29	36	38	300	301
Development Wells												
Oil	18	29	17	28	29	16	14	14	12	14	90	101
Gas	2	1	6	16	2	4	1	0	10	13	21	34
D&A	14	7	43	47	28	34	11	13	3	10	99	111
Total	34	37	66	91	59	54	26	27	25	37	210	246
Service Wells												
WI	13	0	0	1	0	0	0	1	0	0	13	2
BDW	1	2	4	0	7	2	0	0	0	0	12	4
GS	13	34	0	0	12	2	0	0	0	7	25	43
LPG	0	0	0	0	0	1	0	0	0	0	0	1
Total	27	36	4	1	19	5	0	1	0	7	50	50
Total Completions	98	104	204	243	141	111	56	57	61	82	560	597

(1) Includes extension discovery to Morton Gas Field, Mecosta County.

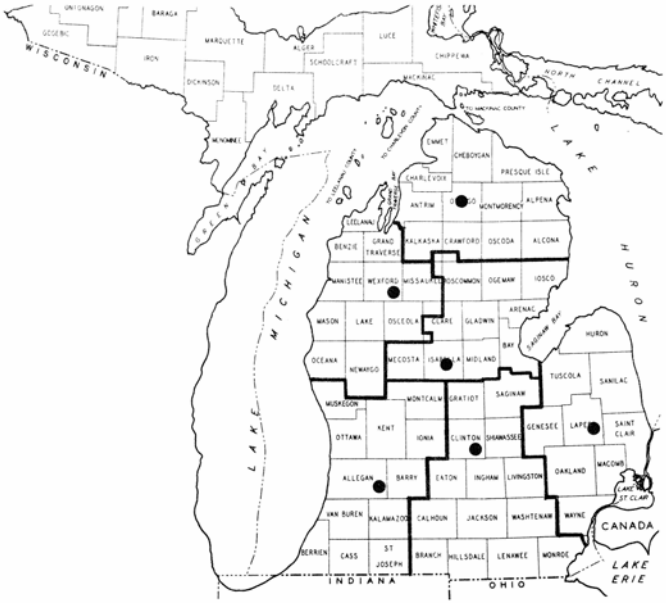
(2) Includes one oil well discovery resulting from reopening and completion of a dry hole credited to 1974.

GEOLOGY DIVISION FIELD OFFICES

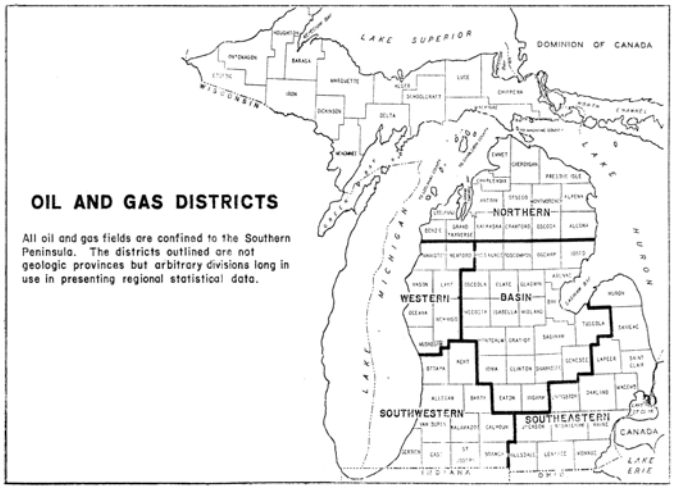
DNR REGION II FIELD OFFICES
Gaylord (Otsego County)
Cadillac (Wexford County)
Mt. Pleasant (Isabella County)

DNR REGION III FIELD OFFICES
Rose Lake (Clinton County)
Plainwell (Allegan County)
Imlay City (Lapeer County)

Dots show the general location of field offices within the several districts. These districts are arranged for administrative and regulatory purposes. Though frequently called oil-and-gas districts, they should not be confused with those shown below which have been in use for many years in presenting statistical data.



[Oil and Gas Districts Map]



Drilled footage. The average depth, statewide, of exploratory wells drilled in 1977 was 4,900 feet compared with 4,830 feet in 1976. Development well depths averaged 4,343 feet compared with 4,350 feet in 1976. Service wells drilled in 1977 averaged 1,830 feet as compared with 2,120 feet in 1976. Drilled footage figures and average well depths for specific counties are shown in Table 1.

Total drilled footage figures from the Geological Survey Division records for 1977 and several prior years are as follows:

DRILLED FOOTAGE FIGURES-GEOLOGICAL SURVEY DIVISION

Well Class	1974	1975	1976	1977
Exploratory	1,374,285	1,397,144	1,448,933	1,474,814
Development	829,709	1,124,863	913,530	1,068,429
Service Wells (All types)	151,661	71,919	105,975	91,492
Total:	2,355,655	2,593,926	2,468,438	2,634,735

Drilled footage figures are furnished to the American Petroleum Institute and these are published as part of their quarterly and annual summary. Drilled footage

figures extracted from the 1977 API Annual Summary are as follows:

1977 API DRILLED FOOTAGE FIGURES

Exploratory Wells			Development Wells		
Oil	Gas	Dry	Oil	Gas	Dry
175,479	148,647	1,255,240	448,334	142,737	550,637

Total Exploratory Footage: 1,579,366 feet*
*API Table II, page 16

Total Development Footage: 1,141,708**
**API Table III, page 17

The difference in total drilled footage figures as reported by API and by the Geological Survey Division are related to factors previously mentioned. API footage figures are correct on the basis of reporting year criteria.

* * * 1977 OIL AND GAS PRODUCTION * * *

Oil and gas production figures are derived from Michigan Department of Treasury tax records and records submitted to the Production-Proration Unit, Oil and Gas Section, Geological Survey Division, Department of Natural Resources. Treasury Department records are primarily concerned with gross production figures needed to calculate revenues. These data are supported by records and reports required from producing companies and purchasers by the Geological Survey Division. Delays in reporting and methods of reporting used by producing companies and purchasers in handling crude oil and stable condensate from gas wells results in a continuous correction and refinement of production figures. Consequently all monthly, year-end, or other production figures are subject to corrections as warranted.

Oil production, including stable condensate, amounted to 32,964,503 barrels in 1977, showing an increase of over 2,500,000 barrels from the previous year. Up by almost 13,000,000 Mcf from 1976 totals, this year's gas production stood at 133,226,452 Mcf. These gains are directly related to the continued development of Salina-Niagaran reef reservoirs in the northern and southern parts of Michigan's Lower Peninsula. With the completion of new pipeline gathering facilities, an increasing number of wells, particularly in the northern Niagaran reef trend, are coming on production and helping to boost Michigan's production figures. The spread of these reef fields across the northern Lower Peninsula is shown on the map accompanying Table 2. Table 2 lists all the Salina-Niagaran reef fields and pools assigned to the northern reef belt. Table 3 lists all other fields and pools including Salina-Niagaran found in the southern part of the basin. Annual and cumulative production figures by year and by geologic formation are found in Part 3 of this and preceding annual summaries.

[Oil and Gas Production by County]

OIL AND GAS PRODUCTION BY COUNTY IN 1977

County	Barrels Oil	MCF Gas
Allegan	119,855	26,684
Antrim	291,213	1,422,711
Arenac	182,385	0
Barry	8,626	0
Bay	176,217	0
Benzie	28,175	28,827
Calhoun	1,663,128	5,222,287
Cass	17,353	0
Clare	322,295	57,924
Crawford	1,155,346	1,379,299
Eaton	409,872	3,115,463
Genesee	21,559	0
Gladwin	271,465	0
Grand Traverse	4,390,810	44,980,090
Gratiot	10,253	3,008
Hillsdale	1,097,890	3,571,779
Ingham	2,186,817	4,082,701
Isabella	134,817	0
Jackson	316,286	2,404,481
Kalkaska	3,025,639	23,603,719
Kent	55,770	753
Lake	83,452	0
Lapeer	120,267	27,961
Livingston	1,878	949,325
Macomb	4,655	1,877,422
Manistee	6,646,012	18,995,369
Mason	304,155	3,448,206
Mecosta	29,547	45,785
Midland	157,126	0
Missaukee	592,958	523,537
Monroe	3,398	0
Montcalm	73,396	0
Muskegon	6,592	0
Newaygo	16,393	0
Oakland	1,972	223,900
Oceana	27,090	0
Ogemaw	591,099	158,071
Osceola	180,052	26,404
Oscoda	858	0
Otsego	6,233,980	12,973,767
Ottawa	61,588	0
Presque Isle	4,362	0
Roscommon	357,517	248,043
Saginaw	15,338	0
Shiawassee	5,633	0
St. Clair	893,753	1,642,377
Tuscola	49,724	68,501
Van Buren	10,363	0
Washtenaw	2,528	0
Wayne	7,585	0
Wexford	595,461	2,118,058
Totals	32,964,503	133,226,452

OIL AND GAS PRODUCTION BY DISTRICT IN 1977

District	Barrels Oil	MCF Gas
Basin	5,768,070	8,329,437
Northern	15,130,383	84,388,413
Southeastern	2,450,212	10,697,245
Southwestern	1,936,683	5,249,724
Western	7,679,155	24,561,633
Totals	32,964,503	133,226,452

OIL AND GAS PRODUCTION BY MONTH IN 1977

	Barrels Oil	MCF Gas
January	2,622,133	10,661,656
February	2,476,109	10,828,926
March	2,822,540	11,843,720
April	2,718,221	10,776,743
May	2,819,039	9,788,045
June	2,847,993	11,167,930
July	2,851,407	11,226,428
August	2,829,735	10,519,191
September	2,705,739	9,991,990
October	2,794,888	12,864,558
November	2,663,548	11,788,511
December	2,813,151	11,768,844
Totals	32,964,503	133,226,542

* * * NATURAL GAS LIQUIDS * * *

The amount of liquids produced from gas-condensate reservoirs associated with northern and western Michigan Silurian reefs decreased during 1977. These liquids, produced from wells classified as gas wells, are included in the yearly oil production totals shown in tabulations in this publication. Wells officially determined to be gas wells are assigned to the Public Service Commission for well connection permits and determination and jurisdiction of gas production rates. There is no restriction on the amount of liquids produced along with the gas. Gas plants operated by Shell Oil Company and Amoco Production Company in Kalkaska County strip natural gas liquids from the gas. The liquids are then sold to another company through the Shell pipeline that terminates at Marysville, Michigan.

An attempt has been made to maintain records of condensate production from the northern reef reservoirs discovered since 1969. Production-Proration Unit records show the following figures for condensate liquids:

CONDENSATE PRODUCTION

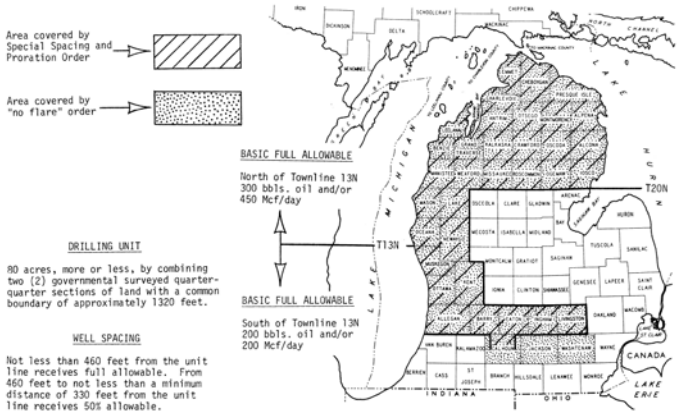
Year	Barrels
1969	0
1970	18,946
1971	98,668
1972	125,768
1973	335,041
1974	1,187,498
1975	1,863,338
1976	1,896,870
1977	1,991,330
Total	7,517,459

Gas plant operations are summarized in Table 6. It should be noted that the LPG recovery figures for the Amoco and Shell plants in Kalkaska County include stabilized condensate as well as LPGs.

A no-flare order, enacted as a conservation measure, prohibits the flaring of oil-well gas and requires Salina-Niagaran oil wells in specified counties to be shut-in until a market connection is achieved for the sale of the gas or an exception to the order is granted. Consequently, Special Order No. 3-71, amended, in effect since late 1971, tends to temporarily curtail production from Salina-Niagaran oil wells until gas gathering pipelines are laid and connections made.

Another order, Special Order No. 1-73, deals with spacing and proration of Salina-Niagaran wells in specific counties. This order established basic 80-acre drilling units (either stand-up or lay-down units) for Salina-Niagaran oil and/or gas wells and statewide proration for Salina-Niagaran oil reservoirs in the specified counties or parts of counties covered by the order. The area covered by the no-flare order and the spacing-proration order are shown on the map below along with information on the drilling unit, well spacing, and basic oil-gas allowables. These prudent and justifiable conservation measures effectively prevent waste of millions of cubic feet of valuable and much needed gas that might have been flared in past years, and these measures should ultimately result in more efficient drainage of reef reservoirs and a greater recovery of the liquid hydrocarbons.

[Special Orders: No Flare, Spacing and Proration, Explanation]



* * * OIL AND GAS VALUATION * * *

Records maintained by the Production-Proration Unit indicate the average price paid at the wellhead in 1977 for Michigan crude oil, including condensate, was $10.95 per barrel compared with $10.84 per barrel in 1976. The gross value of these products amounted to $360,994,743 as compared with $329,636,770 in 1976. The value of Michigan produced natural gas continued to rise in 1977. The average price of gas sold at the wellhead was $1.10 per Mcf as compared with $.878 per Mcf in 1976. The gross value of this product amounted to $145,969,976 in 1977 as compared with $105,597,433 (corrected figure) in 1976.

* * * OIL AND GAS IMPORTS AND EXPORTS * * *

Total imports to Michigan refineries of U.S. domestic and foreign and Canadian crude oil amounted to 31,126,627 barrels in 1977, a decline from the 36,823,603 barrels imported in 1976. Imports of U.S. domestic and foreign crude to Michigan refineries increased from 19,366,106 barrels in 1976 to 22,890,304 barrels in 1977. Imports of Canadian crude via pipeline from western Canada oil fields continued to decline. Canadian imports amounted to 17,457,497 in 1976 but declined to 8,236,323 in 1977.

The trend of U.S. domestic and foreign and Canadian imports to Michigan refineries from 1962 through 1977 is shown graphically. Imports by month during 1977 are as follows:

1977 CRUDE OIL IMPORTS (Bbls.)

	Domestic and Foreign	Canadian	Total
January	2,101,447	1,309,100	3,410,547
February	2,026,250	1,149,000	3,175,250
March	2,485,461	1,264,169	3,749,630
April	2,111,361	961,006	3,072,367
May	2,209,333	719,082	2,928,415
June	1,862,232	499,873	2,362,105
July	1,720,175	414,802	2,134,977
August	1,516,743	244,129	1,760,872
September	1,346,636	339,683	1,686,319
October	1,070,062	214,902	1,284,964
November	1,750,688	659,464	2,410,152
December	2,689,916	461,113	3,151,029
Total	22,890,304	8,236,323	31,126,627

Most Michigan produced crude oil goes to Michigan refineries but some is exported. The amount credited to out-of-state terminal decreased from 7,753,993 barrels in 1976 to 7,241,754 barrels in 1977. Records kept by the Production-Proration Unit show the following exports, by month, of Michigan produced crude:

1977 CRUDE OIL EXPORTS (Bbls.)

January	591,648
February	413,712
March	732,223
April	725,976
May	769,025
June	704,820
July	667,452
August	496,860
September	749,974
October	571,955
November	431,407
December	386,702
Total	7,241,754

Natural gas imports to Michigan markets and gas storage fields in 1977 via interstate pipelines, primarily from Texas, Louisiana, Oklahoma, and Kansas fields, amounted to 772,470,777 Mcf, a decrease from the 793,678,469 Mcf imported in 1976. Compilations by the Office of Gas Operations, Michigan Public Service Commission, show the following monthly imports during 1977:

1977 PIPELINE GAS IMPORTS (Mcf)

January	35,441,580
February	47,186,542
March	69,418,554
April	75,846,218
May	84,418,555
June	75,847,931
July	82,627,432
August	76,373,036
September	82,097,163
October	68,611,313
November	41,756,806
December	32,845,647
Total	772,470,777

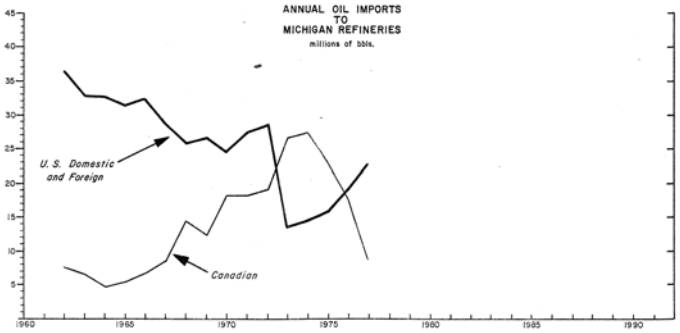
* * * NEW FIELD AND POOL DISCOVERIES * * *

Once again Silurian reefs were the main type of oil and gas trap found in 1977. All appear to have been located by seismic exploration methods. Most were found along the northern reef trend extending from Mason County to Presque Isle County. Others were found in the southern part of the basin in the Calhoun-Eaton-Ingham County area, and in the Macomb-St. Clair County area of the Southeastern District. Of the 71 exploratory wells initially classified as 1977 discovers, 66 were Niagaran reef reservoirs.

All the new discoveries are tentatively classified as Class E pools having possible oil and gas recoveries as defined by the Committee of Statistics of Drilling, American Association of Petroleum Geologists. These classes, shown below, are used to give some estimate or measure of reserves found by a discovery well.

Class A - Over 50 million barrels oil or 300 BCF gas
Class B - 25-50 million barrels oil or 150-300 BCF gas
Class C - 10-25 million barrels oil or 60-150 BCF gas
Class D - 1-10 million barrels oil or 6-60 BCF gas
Class E - 1 million barrels or less oil, or less than 6 BCF gas
Class F - Abandoned as non-profitable

Michigan wells are initially classified as near as possible according to guidelines established by AAPG and API (AAPG Bulletin, Vol. 58/8, August 1974, pp. 1501-1503). Classifications such as exploratory, development, and the various types of service wells, are made after inspection of appropriate oil and gas maps and noting the location of the test in reference to established fields, dry holes, etc. Gas storage facility wells, water injection wells and other types of service wells are generally designated as such by the operator. The Lahee classification system for designating exploratory or development wells is particularly adaptable to structural traps but does not adapt to all situations involving small reefs such as are found in Michigan. Because of the apparent small area! extent of most reefs as shown by seismic anomalies and the close proximity of one reef to another, expecially in the northern and southern reef belts, it has become increasingly difficult to classify with certainty all new well locations as exploratory or development.



1977 DISCOVERY WELLS

County Location	Field Name	Operator and Lease	Permit Number	Depth to Pay	Total Depth	Initial Production n=(N)IP BOPD	t=(T)IP MCFGPD	Producing Formation	Basis for Loc.	AAPG Pool Class
NEW FIELDS										
Calhoun 15-1S-4W	Clarence	J.O. Mutch Lynn Est.& DeBruyn Prod.Co.#1-19	31766	3090	3355		20[t](est.)	Salina-Niagaran	Seis.	E
Calhoun 11-1S-5W	Lee	Wagner Drilling Kay & Hogle #2-11	31447	3260	3395	F 120[t]		Niagaran	Acreage	E
Calhoun 15-1S-5W	Lee	MGU Dev.Co.,Hus.Markel & Wood Kayl et al #2-15	31455	3164	3300	218[t]		Niagaran	Seis.	E
Calhoun 15-1S-5W	Lee	Fortuna Oil & M.Z.Sokolowski Williams #1-15	31720	3210	3225	20 +200 BWD		Niagaran	Acreage	E
Calhoun 30-1S-5W	Lee	MGU Dev. Co. McLain & Lambrecht #1-30	31583	2939	3100		1200[t]	Niagaran	Seis.	E
Calhoun 30-1S-5W	Lee	MGU Dev.Co.,Mask & Markel Flynn #2-30	31893	2988	3104	93 +94 Mcf[t]		Salina A-1 Carb.	Seis.	E
Crawford 24-28N-4W	Frederic	Shell Oil Co. Salling-Hansen #1-24	31409	6991	7577		144 Cond/Day +1700[t]	Niagaran	Seis.	E
Crawford 27-28N-4W	Frederic	Michigan Oil Co. Bender&Salling&Hansen&Frederic#1-27	31145	6912	7441		100 Cond/Day +4250[t]	Salina-Niagaran	Seis.	E
Eaton 7-2N-3W	Eaton Rapids	Kulka & Scheidt & Mich. Oil Co. Mulkey-Yerhele #1-7	31990	4012	4362		SIGW-Gauge Not Available	Niagaran	Seis.	E
Eaton 12-1N-3E	Hamlin	Trolz & Assoc. Rottenbacher-Kress et al #1	31739	3720	4180	130 +140 Mcf[t]		Niagaran	Seis.	E
Eaton 13-1N-3W	Hamlin	Consumers Power Co. Williams-Teel et al #1-13	31430	3924	4008	F 216 +250 Mcf[t]		Niagaran	Seis.	E
Eaton 22-1N-3W	Hamlin	Kulka & Scheidt & Mich. Oil Co. Hoffman #1-22	31525	3520	4020		2000[t]	Niagaran	Seis.	E
Grand Traverse 22-26N-11W	Blair	NME Co. Shumsky-State-Blair #1-22A	31449*	5592	5862		152 Cond/Day +3700[t]	Niagaran	Seis.	E
Grand Traverse 26-26N-11W	Blair	Shell Oil Co. Weaver et al #4-26	31512	5930	6110		221 Cond/Day +5327	Niagaran	Seis.	E
Grand Traverse 8-26N-10W	East Bay	NME Co. Salon et al #1-8	31637*	5716	6020	282 +299 Mcf[t]		Niagaran	Seis.	E
Grand Traverse 3-25N-12W	Grant	Miller Bros.,NME Co.&Tribal Oil Co. State-Grant #2-3	31205*	5381	5724	272 +200 Mcf[t]		Niagaran	Seis.	E
Grand Traverse 4-25N-11W	Mayfield	Shell Oil Co. Henry et al #2-4	31575	5961	6194	366 +515 Mcf[t]		Niagaran	Seis.	E
Grand Traverse 4-25N-11W	Mayfield	Shell Oil Co. Fraser-State-Mayfield #3-4	31623	5847	6196	F 418 +345 Mcf[t]		Niagaran	Seis.	E
Grand Traverse 16-25N-11W	Mayfield	Shell Oil Co. Bauer-Mikowski et al #8-16B	31784*	6088	6287	552 +763 Mcf[t]		Niagaran	Seis.	E
Grand Traverse 12-25N-11W	Mayfield	Shell Oil Co. Crombette et al #3-12	30096	6449	6685		130 Cond/Day +3937[t]	Salina-Niagaran	Seis.	E
Grand Traverse 13-25N-11W	Mayfield	Shell Oil Co. Medford et al #4-13A	31613*	6461	6714		130 Cond/Day +4729[t]	Niagaran	Seis.	E
Grand Traverse 29-25N-11W	Mayfield	Shell Oil Co. Phoenix Petroleum Corp. #3-29	31426	6391	6610	412 +614 Mcf[t]		Niagaran	Seis.	E
Grand Traverse 33-25N-11W	Mayfield	Shell Oil Co. State-Mayfield #1-33A	31513*	6478	6671		40 Cond/Day +2794[t]	Niagaran	Seis.	E
Grand Traverse 33-25N-11W	Mayfield(Antrim Gas)	Traverse Corp. Weidenfeller #1-33	31356	1804	6746		SIGW-Gauge Not Available	Antrim	Seis.	E
Grand Traverse 25-26N-10W	Paradise	Shell Oil Co. State-Paradise #2-25C	31565*	6554	6751		159 Cond/Day +2953[t]	Niagaran	Seis.	E
Kalkaska 16-28N-5W	Blue Lake	Amoco Production Co. Simpson-St.Blue Lk."A" #1-16	31952	7097	7254	F 312 +370 Mcf[t]		Niagaran	Seis.	E
Kalkaska 17-28N-5W	Blue Lake	Amoco Production Co. St.-Blue Lake "G" #3-17	31788	6850	7070		190 Cond/Day +4000[t]	Niagaran	Seis.	E
Kalkaska 18-28N-5W	Blue Lake	Amoco Production Co. AuSable Trails #2-18	31663*	6885	7089		120 Cond/Day +3000[t]	Niagaran	Seis.	E
Kalkaska 23-28N-5W	Blue Lake	Shell Oil Co. Richman-St.-Blue Lk.#1-23	31970	6785	7440		216 Cond/Day +3164[t]	Salina-Niagaran	Seis.	E
Kalkaska 32-28N-5W	Blue Lake	Amoco Production Co. St.-Blue Lk."H" #1-32	31318	7120	7573		20 Cond/Day +4000[t]	Niagaran	Seis.	E
Kalkaska 28-28N-6W	Cold Springs	Amoco Production Co. Simpson Unit "M" #2-28	31693*	6882	7156	F 312		Niagaran	Seis.	E
Kalkaska 31-28N-6W	Cold Springs	Amoco Production Co. Short-St.-Cold Springs Unit#-32	31274*	6870	7025	F 418 +290 Mcf[t]		Niagaran	Seis.	E
Kalkaska 3-27N-7W	Kalkaska	Shell Oil Co. State-Kalkaska #1-3	31522	6647	6827	316 +380 Mcf[t]		Niagaran	Seis.	E
Kalkaska 23-27N-7W	Kalkaska	Shell Oil Co. Badder et al #1-23A	31656*	7027	7166		210 Cond/Day +4198[t]	Niagaran	Seis.	E
Macomb 24-4N-14E	Lenox	Reef Petroleum Corp. Pilat et al #1-24	31492	2780	2900		750[t]	Niagaran	Seis.	E
Manistee 1-23N-15W	Bear Lake	Shell Oil Co. Hayes #3-1	31874	4538	4790	408 +290 Mcf[t]		Niagaran	Seis.	E
Manistee 17-23N-15W	Bear Lake	Shell Oil Co. Hejl-St.-Bear Lake #1-17	31940	4429	4528	354 +370 Mcf[t]		Niagaran	Seis.	E
Manistee 18-23N-15W	Bear Lake	Shell Oil Co. Valentine et al #1-18	31598	4361	4547		65 Cond/Day +5750[t]	Niagaran	Seis.	E
Manistee 35-23N-15W	Bear Lake	Miller Bros.,Reef, Shell & Total Miller-Bear Lake #1-35	31422	4839	4905		500 Cond/Day +50,000[t]	Niagaran	Seis.	E
Manistee 19-22N-15W	Brown	Shell,NME,Total,MillerBros&Wiser Fink et al #1-19	30770	4456	4575		698[t]	Salina-Niagaran	Seis.	E
Manistee 19-24N-13W	Cleon	Miller Bros.,Total & Wiser Oil State-Cleon #2-19	31485	5007	5450	18 + 36 Mcf[t]		Niagaran	Seis.	E
Manistee 24-24N-13W	Cleon	Miller Bros,NME Co.& Total State-Cleon et al #2-24	31804	5857	6052		23 Cond/Day +213[t]	Niagaran	Seis.	E
Manistee 27-24N-13W	Cleon	Miller Bros,Total,Wiser & Mich.Oil Lyke & Leik #2-27	31777	5724	5860		171 Cond/Day +148,000[t]	Niagaran	Seis.	E
Manistee 31-24N-13W	Cleon	Shell Oil Co. Drotleff #1-31	31873*	5220	5543		92 Cond/Day +4461[t]	Niagaran	Seis.	E
Manistee 32-24N-13W	Cleon	Shell Oil Co. State-Cleon et al #1-32A	31894*	5418	5683		109 Cond/Day +3031[t]	Niagaran	Seis.	E
Manistee 14-22N-16W	Manistee	Shell Oil Co. Gauthier et al #1-14	30535	4342	4881	F 51		Niagaran	Seis.	E
Manistee 17-22N-16W	Manistee	Shell Oil Co. Commerce Investment et al #1-17	31737	4116	4285	408 +394 Mcf[t]		Niagaran	Seis.	E
Manistee 18-22N-16W	Manistee	Energy Acquisition & Flynn Energy BGAL Investments et al #2-18	31636	3902	4130	F 220 in 7 hrs.		Niagaran	Seis.	E
Manistee 24-22N-16W	Manistee	Shell Oil Co. Bahr et al #4-24	30812	4677	4776	225 +400 Mcf[t]		Niagaran	Seis.	E
Manistee 25-22N-17W	Manistee	Traverse Corp. Sobota #1-25	31899	4040	4230	143 +41.8Mcf[t]+167BWD		Niagaran	Seis.	E
Manistee 30-23N-14W	Maple Grove	Traverse Corp. Ziehm #1-30	31362	4598	5190		7500[t]	Niagaran	Seis.	E
Manistee 6-23N-13W	Marilla	Reef Petroleum Corp. State-Marilla #1-6	31467	5015	5505		80 Cond/Day +2100[t]	Niagaran	Seis.	E
Manistee 25-24N-15W	Pleasanton	Getty Oil Co. State-Pleasanton #1-25	31481*	4490	4775	148 +185 Mcf[t]		Niagaran	Seis.	E

1977 DISCOVERY WELLS CONTINUED

Missaukee 31-22N-6W	Falmouth-Traverse Pool	Woods Oil Co. Agema #1	31493	3166	3187		550[t]	Traverse	Acreage	E
Missaukee 31-22N-6W	Falmouth-Richfield Pool	Dart Oil & Gas Corp. Mohook #1-31	31967	5111	5261	100 +190 Mcf[t]		Richfield	Acreage	E
Oakland 1-3N-11E	Avon	Reef Petroleum Corp. S & P Investment #1-1	31763	N.A.	3460		SIGW-Gauge Not available	Niagran	Seis.	E
Otsego 31-30N-3W	Bagley	Shell Oil Co. State-Bagley #2-31	31487	6121	6385	498 +504 Mcf[t]		Niagaran	Seis.	E
Otsego 13-31N-2W	Dover, Sec. 13	Wolverine Gas & Oil & Mich.Nat. Res. Co. Doyle #1-13A	31380*	1134	5451		44[n]	Antrim	Seis.	E
Otsego 23-31N-2W	Dover	Delta Oil Co. Blanzy-Schrader #1-23	31870*	5119	5334	189 +222Mcf[t]		Niagaran	Seis.	E
Otsego 11-29N-3W	Otsego Lake	Amoco Production Co. State-Otsego Lake "B" #1-11	31392	6628	6725	F 404 +300 Mcf[t]		Niagaran	Seis.	E
Otsego 22-29N-3W	Otsego Lake, Sec. 22	Murell L. Welch State-Otsego Lake #1-22	31174	1500	1600		.1[n]	Antrim	Acreage	E
Otsego 24-29N-3W	Otsego Lake	Shell Oil Co. State-Otsego Lk-Viking Club#624B	31727*	6561	6803	308 +410 Mcf[t]		Niagaran	Seis.	E
Otsego 31-29N-3W	Otsego Lake	Shell Oil Co. State-Otsego Lake #1-31	31246	6392	6848	500 +1036 Mcf[t]		Niagaran	Seis.	E
Otsego 35-29N-3W	Otsego Lake	Shell Oil Co. State-Otsego Lake et al #1-35	31169	6412	7115		192 Cond/Day +3147[t]	Salina-Niagaran	Seis.	E
Presque Isle 10-34N-5E	Belknap	Amoco Production Co. Lamb #1-10	31787	2960	3087		3190[t]	Niagaran	Seis.	E
Presque Isle 21-34N-5E	Belknap	Amoco Production Co. Berg-Brege Unit #1-21	31657	2978	3340	312 + 52 Mcf[t]		Niagaran	Seis.	E
Presque Isle 34-34N-5E	Belknap	Shell Oil Co. Taratuta et al #1-34A	31400	3153	3410	400 +1432 Mcf[t]		Niagaran	Seis.	E
Presque Isle 12-34N-4E	Bismark	Amoco Production Co. St.-Bismark-Furhrmann Unit"B"#1-12	31528	3017	3237	48 +800 Mcf[t]		Niagaran	Seis.	E
Wexford 6-24N-11W	Wexford	Shell Oil Co. Sullivan #1-6B	31355*	6231	6640		58 Cond/Day +3096[t]	Niagaran	Seis.	E
Wexford 2-24N-12W	Wexford	Ind.Nat. Gas Corp. Kellogg-Clous #1-2A	31454*	6156	6267		348 Cond/Day + 4300[t]	Niagaran	Seis.	E
Wexford 3-24N-12W	Wexford	Shell Oil Co. Courtade-Myers #1-3	31280	6077	6324		150 Cond/Day +3502[t]	Niagaran	Seis.	E

*Directionally drilled hole. Total depth listed is the true vertical depth and not the measured depth. Depths to pay are also true vertical depths.

(1)Well was originally drilled as a development well in the Mayfield 12-25N-11W field. Reclassified as a new pool discovery by administrative action in January, 1977.

Note: t = (T)IP refers to initial production after acid, sandfracture, or a combination of well stimulation methods.
n = (N)IP refers to natural initial potential or production
Cond. = Barrels condensate

The wells listed as 1977 Niagaran reef discoveries are subject to reclassification as to product. Future development may also indicate reservoir connection with a nearby reef reservoir previously classified as a discovery and thus reclassified to development well status.

Discovery wells credited to 1977 are shown on the forthcoming list. The list may show a few wells that were reclassified during 1978. Reservoir performance may show that a well previously classified as a development well should actually be considered as being in a separate reservior or pool. Likewise, a so-called discovery well may actually turn out to be a development well to a nearby reef reservoir. Also, a discovery well may be completed as an oil well but at sometime later be reclassified as a gas well and conversely, a gas well may later be reclassified as an oil well. Changes in classification may be the result of action by the regulating agency after enough data has been accumulated on the well or wells, or may result from new data presented at public hearings and the decision of the Supervisor of Wells after thorough consideration of the new data.

An analysis of 1977 discovery wells according to geologic system and an analysis of drilling objective penetrated at total depth by wells completed in 1977 follows.

ANALYSIS OF 1977 DISCOVERY WELLS BY GEOLOGIC SYSTEM

System	Formation or Pay	Number of Discoveries 1975	1976	1977
Pennsylvanian		-	-	-
Mississippian	"Michigan Stray Ss."	-	1	-
	"Berea Sandstone"	-	-	-
Devonian	Antrim Shale (Gas)	-	-	3
	"Traverse Lime"	1	2	1
	Dundee	1	1	-
	"Reed City"	-	-	-
	Detroit River "Sour Zone"	-	-	-
	Richfield	1	-	1
Silurian	Salina E Zone	1**	-	-
	Salina A-1 or A-2	3	-	1
	Niagaran reef*	68	62	65
Ordovician	Trenton-Black River	-	-	-
	Prairie du Chien	-	-	-
Cambrian	(Gas Shows reported in past years)			

*Most reefs also have associated Salina A-1 oil or gas pays.
**This well was a dual discovery in both the Salina E Zone and the Niagaran.

DRILLING OBJECTIVES IN MICHIGAN

System	Formation or Pay	Percentage 1975	1976	1977
Pennsylvanian		-	-	-
Mississippian	"Michigan Stray Ss."	5.1	4.1	7.7
	"Berea Sandstone"	.2	.5	-
Devonian	Antrim Shale (Gas)	-	-	.7
	"Traverse Lime"	2.6	5.2	4.2
	Dundee	4.2	9.2	6.7
	"Reed City"	1.8	.5	.2
	Detroit River "Sour Zone" & Richfield	3.9	4.0	2.7
Silurian	Salina-Niagaran	77.0	72.5	70.5
Ordocician	Trenton-Black River	3.2	2.9	5.9
	St.Peter Ss. or Prairie du Chien	1.6	.9	1.1
Cambrian or Precambrian	Undifferentiated	.7	.2	.3

* * * STATE OIL AND GAS REVENUE * * *

Total State revenue credited to 1977 and derived from royalty, rental, bonus from lease sales, and application-assignment fees amounted to $14,878,602.78. This figure is derived from these components.

Hydrocarbon royalties	
Oil and Condensate	$ 8,918,556.86
Gas, Casinghead gas, LPG and Shut-in royalty	4,409,351.58
Subtotal	$13,327,908.44
Rentals	$ 1,190,619.60
Bonus	357,005.74
Application-Assignment fees	3,069.00
Subtotal	$ 1,550,694.34
Total Revenue	$14,878,602.78

Oil and gas revenue figures according to year and source are found in Part 3.

* * * WELL RECORDS AND OIL AND GAS MAPS * * *

OIL AND GAS WELL RECORDS. Descriptive geological logs and driller's logs are available for over 31,700 tests, including exploratory, development, facility and other types of wells. Individual well records may be purchased at a nominal cost from the Geological Survey Division. Electric or radiation logs of any type are not available for distribution or sale.

OIL AND GAS FIELD MAPS. Blueprint copies of oil and gas field maps are available for every county in the Southern Peninsula. The maps show locations of oil and gas test but do not show geological data or structural contour lines. County map scales are 1" = 1 mile. Blueprint field maps are available for many oil and gas fields. These maps show well locations, well permit numbers, operators and lease names. They do not show geological data or structural contour lines. Field map scales are mainly 4" = 1 mile. All manuscript maps or tracings from which blueprint copies are made are posted on a regular basis. An oil and gas field maps list may be obtained from the Geological Survey Division upon request.

TABLE 1 DRILLING PERMITS, WELL COMPLETIONS, DRILLED FOOTAGE BY COUNTY, 1977

Classification of New Hole Completions
Does not include reworked wells or old wells drilled deeper.

COUNTY	OIL/GAS PERMITS ISSUED	OIL AND GAS TESTS Completed Explor.	OIL AND GAS TESTS Completed Devel.	RESULTS Oil Wells	RESULTS Gas Wells	RESULTS Dry Holes	SERVICE WELLS Completed G.S.	SERVICE WELLS Completed B.D.W.	TOTAL WELLS DRILLED	TOTAL DRILLED FOOTAGE Explor.	TOTAL DRILLED FOOTAGE Devel.	TOTAL DRILLED FOOTAGE Fac.	Average Well Depth
Allegan	11	7	6	0	0	13	0	0	13	20,667	11,985	0	2,512
Alpena	2	1	1	0	0	2	0	0	2	3,895	4,263	0	4,079
Antrim	4	3	2	1	0	4	0	0	5	20,624***	13,536	0	6,832
Arenac	6	2	0	0	0	2	0	1	3	6,215	0	3,101	3,105
Bay	3	1	2	0	0	3	0	0	3	3,375	11,016	0	4,797
Benzie	5	4	1	1	0	4	0	0	5	22,173	5,976	0	5,630
Branch	1	4	0	0	0	4	0	0	4	14,690	0	0	3,673
Calhoun	35	15	10	9	2	14	0	1(1)	26	50,272	31,088	1,986	3,206
Cass	13	0	9	8	0	1	0	0	9	0	6,265	247*	724
Cheboygan	3	1	1	0	0	2	0	0	2	4,368	3,950	0	4,159
Chippewa	1	1	0	0	0	1	0	0	1	1,204	0	0	1,204
Clare	7	1	2	2	0	1	2	0	5	3,994	12,245	3,397*	3,927
Crawford	9	2	9	6	2	3	0	1(1)	12	15,018	59,246	4,361	6,552
Eaton	15	8	5	5	2	6	0	0	13	30,592	19,214	0	3,831
Gladwin	2	0	0	0	0	0	0	0	0	0	0	163*	0
Grand Traverse	115	62	45	16	15	76	0	0	107	371,292	254,298	0	5,847
Gratiot	4	1	0	0	0	1	3	0	4	3,248	0	3,336	1,646
Hillsdale	35	1	21	14	0	8	0	0	22	4,206	85,136	0	4,061
Huron	0	1	0	0	0	1	0	0	1	4,900	0	0	4,900
Ingham	16	2	3	2	0	3	0	0	5	7,802	12,549	0	4,070
Isabella	6	2	0	0	0	2	1	0	3	7,799	0	1,219*	3,006
Jackson	2	1	1	0	0	2	0	0	2	4,786	4,420	0	4,603
Kalkaska	45	28	13	10	8	23	0	0	41	191,159	75,079	0	6,494
Kent	1	0	0	0	0	0	1	0	1	0	0	3,988	3,988
Lake	0	0	0	0	0	0	1	0	1	0	0	3,910	3,910
Lenawee	9	3	0	0	0	3	0	0	3	11,802	0	0	3,934
Livingston	8	6	0	0	0	6	0	0	6	31,661	0	0	5,277
Macomb	28	13	11	0	11	13	5	0	29	44,456	40,951	13,852	3,423
Manistee	94	45	38	24	10	49	0	2	85	210,527	166,834	3,025	4,475
Mason	7	3	4	0	1	6	0	0	7	13,514	15,189	0	4,100
Mecosta	26	2	1	1	0	2	22	0	25	7,551	2,778	31,166*	1,660
Midland	3	1	0	0	0	1	0	0	1	4,075	0	0	4,075
Missaukee	18	4	4	5	1	2	0	1	9	15,199	17,018	4,118	4,037
Montcalm	6	1	0	0	0	1	6	0	7	3,251	0	8,268*	1,646
Montmorency	4	5	0	0	0	5	0	0	5	26,123	0	0	5,225
Muskegon	0	0	0	0	0	0	0	0	0	0	5**	0	0
Newaygo	5	0	3	1	1	1	2	0	5	0	8,063	2,672	2,147
Oakland	7	9	2	0	3	8	0	0	11	33,452	7,834	0	3,753
Oceana	4	1	3	1	0	3	0	0	4	1,339	8,744	0	2,521
Ogemaw	9	3	8	8	0	3	0	0	11	17,483	21,918	0	3,582
Osceola	4	2	3	0	1	4	0	0	5	7,719	7,056	569*	3,069
Otsego	46	24	15	9	7	23	0	0	39	142,295	75,552	0	5,586
Ottawa	2	0	0	0	0	0	0	0	0	56***	0	0	0
Presque Isle	27	20	4	3	2	19	0	0	24	68,370	12,742	0	3,380
Roscommon	4	1	3	3	0	1	0	0	4	4,435	13,145	0	4,395
St. Clair	22	4	2	0	1	5	1	0	7	12,432	6,149	2,114	2,956
St. Joseph	3	3	0	0	0	3	0	0	3	11,347	0	0	3,782
Tuscola	6	0	6	6	0	0	0	0	6	0	21,654	0	3,609
VanBuren	1	0	2	1	0	1	0	0	2	0	2,386	0	1,193
Wexford	8	3	6	0	3	6	0	0	9	15,448	30,145	0	5,066
TOTAL	692	301	246	136	70	341	44	6	597	1,474,814	1,068,429	91,492	

*Includes some facility footage credited to old wells drilled deeper.
**Includes some development footage credited to old wells drilled deeper.
***Includes some exploratory footage credited to old wells drilled deeper.
(1) Water injection wells involved in secondary recovery operations.

PART 2

EXPLANATION

Part 2 brings together general information on Michigan's oil and gas fields, gas storage reservoirs, LPG storage facilities, gas plant operations, refinery facilities and other items.

TABLES 2, 3 and 4 list Michigan's oil and gas fields and gas storage reservoirs. The symbol on the left margin of the table indicates the official classification of fields and pools at the end of the year. Classifications may be changed as warranted. Official field names are listed alphabetically in the first column and the producing pool, or pools, are shown under the heading Producing Formation or Pool. Most fields consist of one pool with oil or gas production coming from a single reservoir within a formation. Some fields have two or more separate pools, each producing from a different formation or stratigraphic interval and at a different depth. Most multi-pool fields are associated with a common structural feature. Salina-Niagaran reef oil or gas accumulations are mostly single-pool fields. Some, however, have several separate reef reservoirs designated as Pool A, Pool B and so on. Most have been so designated by administrative action following public hearings. Also, a few of the listed fields actually consist of two or more hydrocarbon accumulations which for administrative purposes have been consolidated under one field name.

Location of fields according to township, range and sections are found at the bottom of the field block. The listed sections are those which have, or have had, producing wells assigned to the field or pool. The geographic location of fields and pools can be found by township and range on the center-spread oil and gas field map. Due to space limitations, all field names are not shown on the map.

The Pay Zone part of the table generally refers to data for the discovery well for the field or pool. The indicated pay thickness relates to the amount of pay opened or perforated in the discovery well and does not necessarily indicate total net or gross pay for the reservoir.

The Deepest Formation or Pool Tested column indicates the stratigraphically oldest formation penetrated and the deepest total depth reached beneath the field area. Data in these columns are updated periodically.

The Number of Wells column indicates the number of successful field wells drilled in the field to the end of the specified year, the number completed as producing wells during the specified year, the number abandoned during the year and the number of active wells at the end of the specified year.

The Drilled Acres column indicates the total number of acres assigned to the field or pool according to individual well drilling units assigned to each producing well completed in the field or pool. Except as provided by special orders covering drilling units, rules promulgated under Act No. 61, P.A. of 1939, as amended, call for a minimum 40-acre unit consisting of a governmental quarter-quarter section of land. Special Order No. 1-73 calls for basic 80-acre drilling units for Salina-Niagaran or deeper tests in specified areas of the state. These 80-acre units are formed by two governmental quarter-quarter sections of land having a common boundary of approximately 1320 feet. In past years drilling units have been 10, 20 or 40 acres for oil wells. A field may have had a 10 or 20-acre drilling unit for one pool and a 40-acre unit for a deeper formation pool. During the development of a field or pool the drilling unit size may change. Subsequent wells are assigned acreage values in accordance with the new unit size. Gas well units, especially for Michigan Stray Sandstone reservoirs, have generally been 160-acre units. Other sizes currently in use for gas wells are 40, 80, 320 and 640-acre units, or a unit size based on seismic and res-servoir data. Reef reservoirs, especially in the northern reef trend, have been assigned 80, 160, 640, or a unit based on seismic data. Changes in drilling units, off-pattern wells, etc., complicate the maintenance of accurate figures during the lifetime of a given field or pool.

Recovery Per Acre Drilled figures for oil pools are derived by dividing the cumulative production figure by the drilled acres figure.

Gas Fields, Gas-Condensate Fields. Some fields are listed as "shut-in" and show no production figures. In the case of Niagaran reef fields classified as gas-condensate reservoirs, virtually all those listed as shut-in at the end of 1977 were waiting pipeline construction or gas-handling facilities. Others, mainly small dry-gas reservoirs in shallower formations, are listed as shut-in because of slow field development, small reserves or lack of marketing facilities. Other fields, not considered to have commerical-size gas accumulations, produce small quantities of unmetered gas which is used for domestic purposes and in some cases, lease fuel.

GAS STORAGE RESERVOIRS. Most gas storage reservoirs were originally classified as gas fields or pools. Upon depletion or near depletion of native gas they were converted to storage reservoirs. The producing sections listed on gas storage reservoir tables do not necessarily relate to current gas storage area or boundaries. The sections or parts of sections listed are those which contained at least one producible oil or gas well assigned to the field or pool prior to conversion to gas storage operations. Further, the listed sections do not necessarily relate to potential or future gas storage area or boundary. The table listing undeveloped gas storage reservoirs has been discontinued.

LPG STORAGE. Surface and underground storage facilities for liquified petroleum gas.

OIL WELL GAS. This is casinghead gas produced incidental to the production of oil from pools or fields generally classified as oil accumulations.

NATURAL GAS LIQUIDS (CONDENSATE). Natural gas liquids are those portions of reservoir gas which are liquified at the surface in lease separators, field facilities, or gas processing plants. These liquids include but are not limited to: ethane, propane, butanes, pentanes, natural gasoline and condensate. On Tables 2 and 3 of this report, condensates from Michigan gas-condensate fields are shown under the oil production column.

WELL SAMPLE SETS. Well cuttings for over 9,000 wells are available for inspection at the Geological Survey Division, Michigan Department of Natural Resources, Lansing. Samples are contained in glass vials arranged in open trays. In addition, several thousand shallow geological test samples are also available for inspection. The Division does not maintain a core collection. Other sample and core repositories, not connected with the Division, are located at:

Subsurface Laboratory, Department of Geology, The University of Michigan, Ann Arbor, Michigan.

Department of Geology, Wayne State University, Detroit, Michigan.

Department of Geology, Western Michigan University, Kalamazoo, Michigan.

Department of Geology, Michigan State University, East Lansing, Michigan.

Department of Geology, Central Michigan University, Mt. Pleasant, Michigan.

PART 3
CUMULATIVE RECORDS

EXPLANATION

PART 3 contains cumulative statistics principally of oil and gas production, well completions, and oil field brine production and disposal from 1925 through the most recent year-end compilations.

OIL AND GAS PRODUCTION TABLES. Oil and gas production figures for individual years prior to 1960 can be found in issues of "Summary of Operations, Oil and Gas Fields" for 1962 and prior years, and in "Michigan's Oil and Gas Fields" 1963 to present. The tables show the year of the first recorded production from a particular formation, and the yearly and cumulative production totals from 1925 through the most recent year-end compilations. Cumulative oil and gas production by county is shown on a separate table. Refer to Part 1 for county production figures for the past year, and prior issues for previous years.

CUMULATIVE WELL COMPLETIONS. These tables show the cumulative number of yearly completions in a county. Well density figures include field development wells, exploratory wells, and service wells of all types.

DRILLING PERMITS, WELL COMPLETIONS, FIELDS DISCOVERED. These tables show the number of drilling permits issued by year from 1927 through the most recent year-end compilations. Initial classification of well completions by year, the number of new fields or pools discovered, and the number of producible oil or gas wells on a yearly basis are all shown on the same table.

BRINE PRODUCTION AND DISPOSAL. Oil field brine production records other than for individual fields were discontinued in 1968. These tables listed the reported amount of produced brine and the method of disposal from 1937 up to 1967. Most oil field brine is still returned to subsurface formations. Small quantities are used for dust control or ice and snow removal on county roads in local areas. A small amount of brine is also disposed of in burning pits.

SERVICE WELLS. Service wells as listed in this publication are those wells which were drilled to serve some purpose other than the initial production of oil or gas. Oil or gas wells are sometimes converted to salt water disposal, observation, or facility wells in gas storage or pressure maintenance projects. There are several types of service wells:

LPG Wells. These are wells drilled for underground storage of liquified petroleum gas. In Michigan, these storage reservoirs are in man-made cavities in salt beds. The cavities have been made by dissolving the salt with water and then pumping out the brine.

Gas Storage Wells. These are wells drilled in gas storage reservoirs. They are frequently referred to as facility wells, and are generally used to inject gas into or extract gas from the reservoir. Certain facility wells may sometime in the history of the field be used as salt water disposal wells or observation wells.

Observation Wells. Most observation wells are related to gas storage projects. They are used to observe underground movement of gas, brines and other fluids, or to observe pressures.

Brine Disposal Wells. These wells are used in the disposal of oil and gas field brines back into some suitable subsurface formation. Brine disposal well permits are issued for these wells.

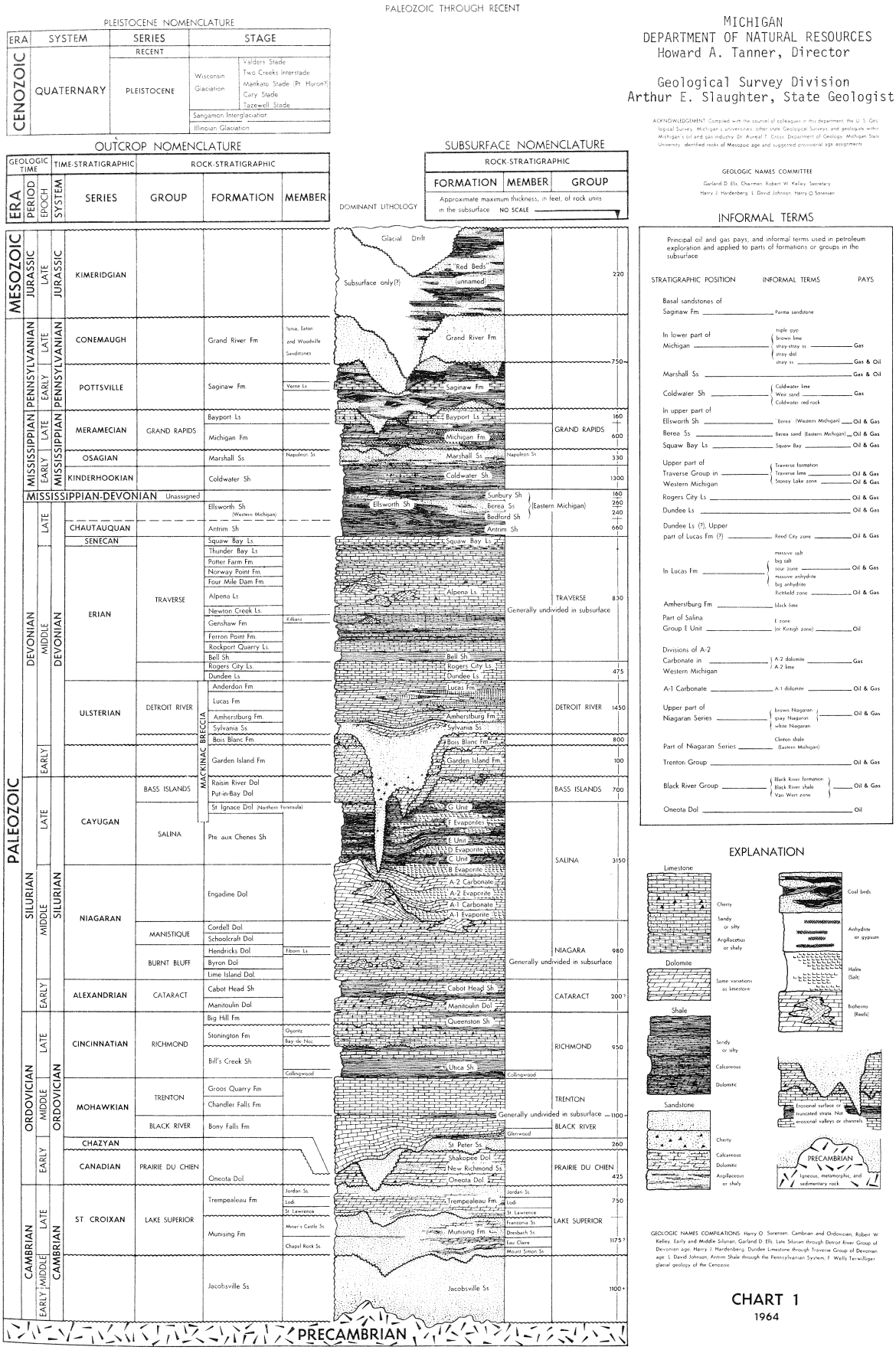
Injection and Pressure Maintenance Wells. These are wells used in secondary recovery, or pressure maintenance projects. They may be new wells drilled specifically for injection or pressure maintenance, or they may be converted oil or gas wells; their status can change from time to time.

Oil or gas wells are sometimes converted to salt water disposal, observation, facility wells in gas storage reservoirs, or water injection wells used in secondary recovery or pressure maintenance projects. The types of service wells listed under "Classification of Well Completions" do not include oil or gas wells converted to service wells.

ABBREVIATIONS

A.A.P.G.	American Assoc. Petrol. Geol.
A.P.I.	American Petroleum Institute
(A) I.P.	(Acid) Initial Production or Potential
A-1 Carb.	A-1 Carbonate
A-2 Carb.	A-2 Carbonate
Bbls.	Barrels
B.B.	Bois Blanc formation
B.D.	Brine Disposal
BDW	Brine Disposal Well
BOPD	Barrels Oil Per Day
B.R.	Black River
Camb.	Cambrian
"Camb."	Unidentified Cambrian
Cat.	Cataract formation
c.f.p.b.	Cubic feet per barrel
C.H.	Cabot Head formation
Cinn.	Cincinnatian
Cl.	Clinton formation
Cold.	Coldwater formation
Compl.	Completion
Coop.	Cooperative
D & A	Dry and Abandoned
Dev.	Devonian
D.R.	Detroit River formation
D.R. SZ	Detroit River Sour Zone
Dres.	Dresbach formation
Dd., DD	Dundee
Dd.-R.C.	Dundee-Reed City
DPT	Deeper Pool Test
E.C.	Eau Claire formation
Explor.	Exploratory
Fran.	Franconia formation
Geo. Test	Geological Test
G.O.R.	Gas-Oil Ratio
Grav.	Gravity, Gravimeter
GS	Gas Storage
GSW	Gas Storage Service Well
Gw	Glenwood
Incs.	Includes
Inj.	Injection
L.P.G.	Liquid Petroleum Gas
Marsh.	Marshall formation
MCF	Thousand Cubic
MCFGPD	Thousand Cubic Feet Gas Per Day
Mich.	Michigan formation
Miss.	Mississippian
M.S.	Mt. Simon ss.
NFW	New Field Wildcat
(N) I.P.	(Natural) Initial Production or Potential
Niag.	Niagaran
Nt.	Nontechnical
OBS	Observation Well
OP	Out Post Well
Ord.	Ordovician
OWDD	Old Well Drilled Deeper
P.D.C.	Prairie du Chien formation
Penn.	Pennsylvanian
Pilot Wtr.	Pilot Water
P.M.	Pressure Maintenance
Prod. Form.	Producing Formation
R.C.	Reed City formation
RW	Reworked Well
Rich.	Richfield formation
Sag.	Saginaw formation
Sal.-Niag.	Salina-Niagaran
SD	Shut Down
Seis.	Seismograph
SO & G	Show Oil and Gas
S.P.	St. Peter formation
Stray	Michigan Stray formation
Sub.	Subsurface geology
SW	Service Well
SWD	Salt Water Disposal
Sylv.	Sylvania formation
SZ	Sour Zone (in Detroit River)
Thick.	Thickness
(T) I.P.	(Treatment) Initial Production or Potential
Trav.	Traverse
Tremp.	Trempealeau formation
Trenton-Blk. River	Trenton-Black River
Unit.	Unitized

STRATIGRAPHIC SUCCESSION IN MICHIGAN



MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
Howard A. Tanner, Director

Geological Survey Division
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GEOLOGIC NAMES COMMITTEE

Garland D. Ells, Chairman; Robert W. Kelley, Secretary
Harry J. Hardenberg; L. David Johnson; Harry O. Sorensen

INFORMAL TERMS

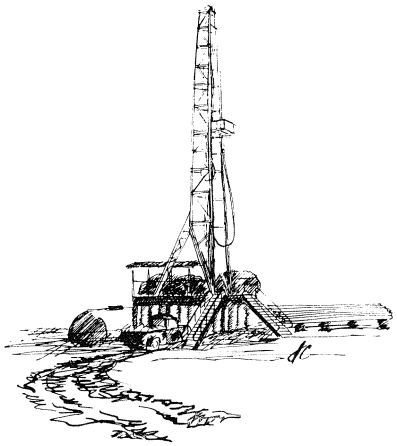
Principal oil and gas pays, and informal terms used in petroleum exploration and applied to parts of formations or groups in the subsurface

STRATIGRAPHIC POSITION	INFORMAL TERMS	PAYS
Basal sandstones of Saginaw Fm	Parma sandstone	
In lower part of Michigan	triple gyp	
	brown lime	Gas
	stray-stray ss	
	stray dol	
	stray ss	Gas & Oil
Marshall Ss		Gas & Oil
Coldwater Sh	Coldwater lime	
	Weir sand	Gas
	Coldwater red rock	
In upper part of Ellsworth Sh	Berea (Western Michigan)	Oil & Gas
Berea Ss	Berea sand (Eastern Michigan)	Oil & Gas
Squaw Bay Ls	Squaw Bay	Oil & Gas
Upper part of Traverse Group in Western Michigan	Traverse formation	
	Traverse lime	Oil & Gas
	Stoney Lake zone	Oil & Gas
Rogers City Ls		Oil & Gas
Dundee Ls		Oil & Gas
Dundee Ls (?), Upper part of Lucas Fm (?)	Reed City zone	Oil & Gas
In Lucas Fm	massive salt	
	big salt	
	sour zone	Oil & Gas
	massive anhydrite	
	big anhydrite	
	Richfield zone	Oil & Gas
Amherstburg Fm	black lime	
Part of Salina Group E Unit	E zone (or Kirtigh zone)	Oil
Divisions of A-2 Carbonate in Western Michigan	A-2 dolomite	Gas
	A-2 lime	
A-1 Carbonate	A-1 dolomite	Oil & Gas
Upper part of Niagaran Series	brown Niagaran	Oil & Gas
	gray Niagaran	
	white Niagaran	
Part of Niagaran Series	Clinton shale (Eastern Michigan)	
Trenton Group		Oil & Gas
Black River Group	Black River formation	
	Black River shale	Oil & Gas
	Van Wert zone	
Oneota Dol		Oil

EXPLANATION

GEOLOGIC NAMES COMPILATIONS: Harry O. Sorensen, Cambrian and Ordovician; Robert W. Kelley, Early and Middle Silurian; Garland D. Ells, Late Silurian through Detroit River Group of Devonian age; Harry J. Hardenberg, Dundee Limestone through Traverse Group of Devonian age; L. David Johnson, Antrim Shale through the Pennsylvanian System; F. Wells Terwilliger, glacial geology of the Cenozoic.

CHART 1
1964



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