NEWSLETTER

NDGS

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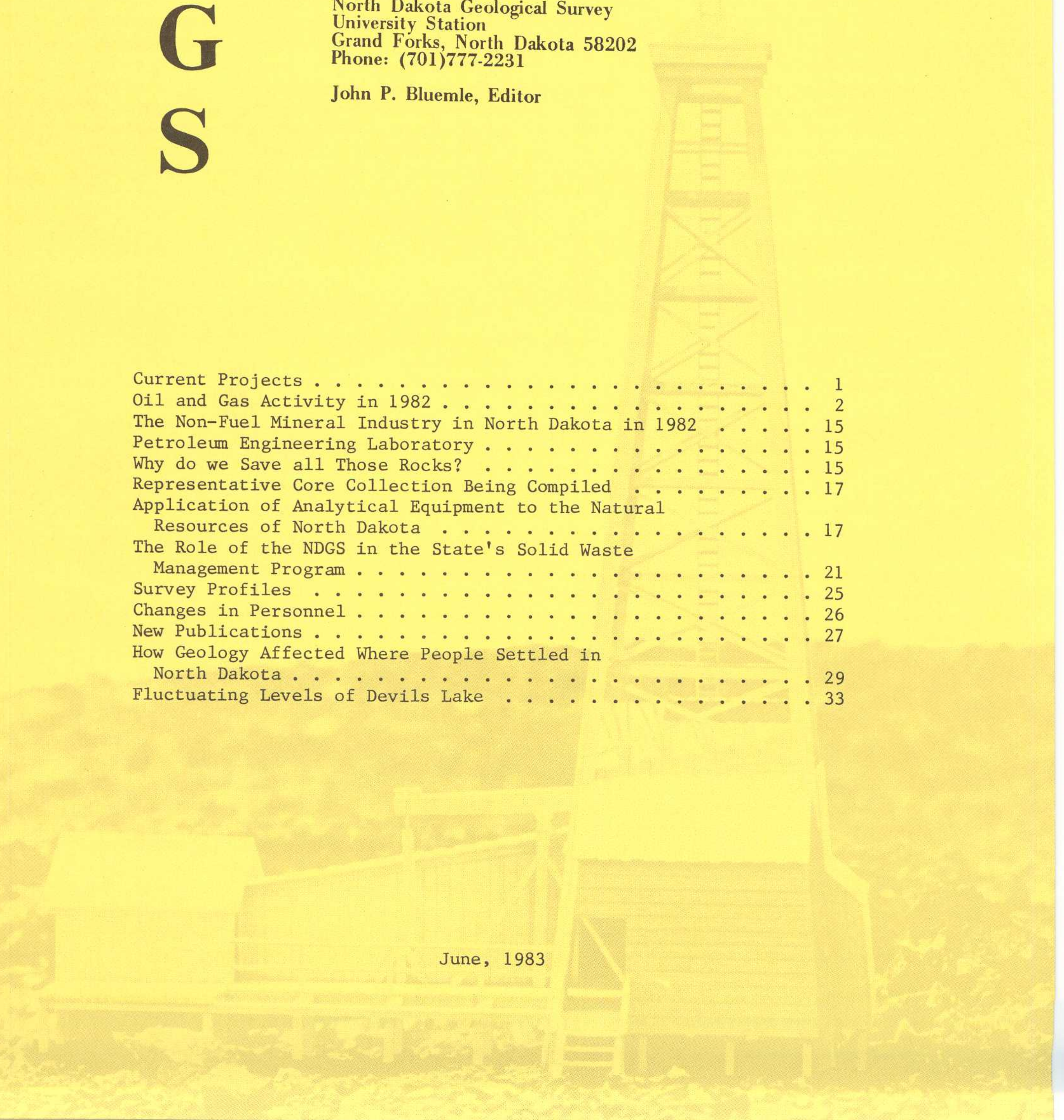

June, 1983

CURRENT PROJECTS

--John Bluemle

The NDGS staff is involved in a variety of projects this summer. Ed Murphy is mapping Dunn County and he expects to eventually extend that study to include a larger 1° x 1° area. Ken Harris is currently field checking a part of the southeastern North Dakota 1° x 1° area. The 1° x 1° studies, which we are undertaking, will be comprehensive geologic studies bringing together a variety of surface, subsurface, engineering, and environmental geologic information into a series of maps for each area. They are, we believe, a logical next step in our general geologic studies of North Dakota, incorporating greater detail and more information into convenient-sized units, approximately 2600 square miles each.

I expect to be field checking a portion of south-central North Dakota, including Emmons County, this summer. Hopefully, I'll then be completing geologic reports on Towner and Emmons Counties next winter. I also expect to be revising a brochure I first wrote about 10 years ago describing the geology along Interstate Highway 94 in North Dakota as well as continuing my work on an atlas of North Dakota's landforms.

In the past few years, several outstanding theses on various aspects of Williston Basin geology were written by University of North Dakota graduate students. The Survey has been reviewing the theses and we hope to publish several of them. The first of these is a report on the Tyler Formation by Steven Sturm (see a description in "New Publications," this Newsletter).

Sid Anderson has been working on a study of the Nesson Anticline and finishing work on a study of the lower Mississippian rocks of east-central North Dakota. Julie LeFever is working on a study of the Spearfish Formation as well as the Nesson Anticline study. Dave Fischer is studying some Silurian salt deposits in the Williston Basin. Tom Obelenus will probably be undertaking a study of the lower Charles Formation evaporites.

Dave Brekke has been writing rules and regulations for underground injection control and for geothermal energy production. He will soon be undertaking a study of the geochemistry of North Dakota's potash resources.

Marv Rygh is currently building a permeameter for testing core plugs and he expects to soon begin work with Min Chu of the University of North Dakota Geology Department on various other aspects of petroleum testing.

Bob Seidel is working on a paleoclimatic study of southwestern North Dakota. A number of lake basins located in this unglaciated area must have been situated close to the margin of the major ice sheets and therefore within a steep climatic gradient. Material collected from these basins is being used to interpret the sedimentologic history of the basins. It should then be possible to ascertain fluctuations in climate and the resulting changes in the position of the ice front. Lake basins in the periglacial geographic setting have not been studied extensively and it is hoped they will provide new and valuable information on periglacial paleoclimates.

John Hoganson continues to carry on research concerned with the environmental and climatic evolution of North Dakota (see last Newsletter) using fossils as indicators of past conditions. Extraction and analysis of fossils from 12,000-year-old sediments being excavated from the now-under-construction McClusky Canal are underway. Additional Quaternary fossil sites are being explored for, primarily in western North Dakota. In addition, John is active in the state's Waste Management Program by evaluating the geological and hydrogeological suitability of proposed solid waste management facilities in the state (see article in this Newsletter). He also is involved in supervising graduate student research projects concerned with waste-management problems.

OIL AND GAS ACTIVITY IN 1982

--John Bluemle

Even though oil and gas exploration activity in North Dakota was down in 1982 compared to the previous year, the number of new oil pools discovered reached a new high. This was due, in part, to a carry-over from 1981 because many wells begun in 1981 were not completed until 1982. Production also reached an all-time high at 47,269,477 barrels of oil in 1982. According to recent statistics from the Oil and Gas Division of the State Industrial Commission, production in North Dakota has now peaked and is declining, so total production in 1983 will probably not reach the 1982 level.

The Oil and Gas Division issued a total of 631 drilling permits in 1982 (unofficial statistics), down from the 1098 permits that were issued in 1981. Of these, 28 percent were for exploration (wildcat wells), 52 percent were to develop already-proven areas, and 14 percent were extensions to areas of known production. A total of 7,080,924 feet of hole was drilled for oil and gas in North Dakota in 1982, compared to 7,869,239 feet in 1981.

Other statistics about North Dakota's oil and gas industry are summarized in figures 1 through 4. Table 1 lists all of the 1982 oil and gas discoveries and includes pertinent statistics about each of these discoveries. Table 2 lists the number of new pool discoveries for each county in North Dakota during 1982 and the number of discoveries from each geologic formation. As usual, McKenzie County had the largest number of discoveries, 51 of the 106 total for the state. Discoveries were made in 12 counties in 1982. The Red River Formation accounted for 36 of the 106 new pool discoveries, the Madison had 22, the Duperow 16, and the Bakken 14.

As I write this, 54 oil rigs are operating in North Dakota. A year ago, 60 rigs were operating so, even though the rig count dropped below 20 at one time this spring, activity seems to be picking up somewhat again.

Table 1. Oil and Gas Discoveries in North Dakota during 1982.

County, File No., Order No.	Comp. Date	Operator, Well, Location	Field, Pool	Spacing	Total Depth	Interval Perforated	Initial Production (Bbls. Oil)	Gravity	GOR	Water %
Billings 8330 3048	09-05-81	Canterra Petroleum BN #3-3 NWNE Sec. 3-141-100	Tree Top-Bakken	160	11,240	-	9	39.6°	425	-
Billings 8601 2745	01-30-82	Cities Service Co. Federal DF #1 NWNW Sec. 6-144-100	Ice Caves-Red River	320	13,460 PBTD 13,647 TD	13,516-13,520	42*	-	42,857	23
Billings 8596 2692	02-12-82	Diamond Shamrock Corp. Federal #11-10 NWNW Sec. 10-142-102	Roosevelt-Duperow	320	12,635	10,828-10,838	336	37.8°	1,062	17
Billings 9200 2633	03-27-82	Adobe Oil & Gas Corp. Kordonowy Twin #34-31 SWSE Sec. 31-142-98	Bullsnake-Duperow	320	12,140	11,311-11,359	503	35°	900	0
Billings 8601 2745	03-03-82	Cities Service Co. Federal DF #1 NWNW Sec. 6-144-100	Ice Caves-Duperow	320	13,460 PBTD 13,647 TD	11,606-11,614	552	40°	833	15
Billings 8972 2788	03-03-82	Everett Drlg Ventures Inc. Federal #5-22 SWNW Sec. 22-143-100	St. Jacobs-Duperow	160	11,486	11,208-11,248	76	44.5°	1,237	63
Billings 8234 2703	03-31-82	Coastal Oil & Gas Corp. BN 29-144-102 #1 NWNW Sec. 29-144-102	Morgan Draw-Madison	160	12,754	9,215- 9,236	152	29.5°	165	60
Billings 8363 2815	05-12-82	Al-Aquitaine BN #1-23 NWNE Sec. 23-143-102	Elkhorn Ranch-Red River	320	12,650	12,470-12,479	60	43°	1,000	34
Billings 9410 2853	05-20-82	Gulf Oil Corp. Zastoupil #1-26-3B NESE Sec. 26-142-98	Snow-Madison	160	10,040	9,668- 9,674	282	40.6°	908	3
Billings 8075 2766	05-30-81	Conoco, Inc. Federal Hanson 8 #1 NESE Sec. 8-142-101	Ash Coulee-Red River	320	12,712	12,508-12,536	43	45.3°	581	0
Billings 9218 2854	03-17-82	Jerry Chambers Expl. Co. Allred Federal #11-1 NESW Sec. 1-144-102	DeMores-Bakken	320	11,050	10,424-10,454	64	40°	1,100	0
Billings 9070 2847	11-22-82	Adobe Oil & Gas Corp. L. Luptak #23-31 NESW Sec. 31-141-99	Park-Madison	320	13,404	12,820-12,842	96*	39°	16,843	68
Billings 8070 2846	10-05-82	Coastal Oil & Gas Corp. BN 19-144-102 #1 SESE Sec. 19-144-102	Morgan Draw-Duperow	320	11,150	10,932-10,984	9	43.5°	163	6
Billings 8070 2846	10-05-82	Coastal Oil & Gas Corp. BN 19-144-102 #1 SESE Sec. 19-144-102	Morgan Draw-Bakken	320	11,150	10,443-10,453	81	43.5°	1,470	57
Billings 9321 2998	10-07-82	Davis Oil Co. Jackrabbit Federal #1 SESE Sec. 8-143-100	Gorham-Duperow	320	13,398	11,423-11,432	253	41°	1,518	1
Bottineau 9299 2755	01-07-82	Leeman Energy Corp. Aune #1 NWSW Sec. 6-162-79	Sergis-Madison	80	3,530	3,343- 3,360	40	32°	-	75
Bowman 9805 3041	11-10-82	Williams Co. Wallman #1 NESW Sec. 32-130-104	Nebo-Red River	160	9,967	9,185- 9,186	52	37°	600	40

County, File No., Order No.	Comp. Date	Operator, Well, Location	Field, Pool	Spacing	Total Depth	Interval Perforated	Initial Production (Bbls. Oil)	Gravity	GOR	Water %
Burke 9151 2649	02-01-82	Resources Invest., Corp. Lostwood #1-11 SWSE Sec. 11-161-90	Lostwood-Madison	80	6,800	6,186- 6,218	492	35.3°	950	-
Divide 9413 2774	04-13-82	Texaco, Inc. Haugland #1 SESE Sec. 16-163-98	Blooming Prairie-Red River	320	11,400	10,791-10,808	338	43.8°	876	5
Divide 9528 2975	08-20-82	Conoco, Inc. Moore #20-1 NWNW Sec. 20-163-102	Skjermo-Red River	320	11,120	10,628-10,650	65	38°	TSTM	31
Divide 9622 2968	08-21-82	Texaco, Inc. Arnold Hegan State #1 NWNW Sec. 10-163-98	CanDak-Red River	320	11,350	10,682-10,692	50	41.7°	1,020	82
Dunn 8491 2679	01-12-82	Mesa Petroleum Co. Bullinger #1-30 NESW Sec. 30-142-96	Russian Creek-Red River	320	13,200	13,042-13,070	72*	60°	15,278	57
Dunn 9044 2680	01-21-82	ANR Production Company Hansen #1-11A SENW Sec. 11-146-93	Wolf Bay-Duperow	320	14,120	10,974-11,022	131	32.2°	220	40
Dunn 8313 2740	02-15-82	Mesa Petroleum Co. Hausauer 22 #1 NWSW Sec. 22-145-93	Lake Ilo-Duperow	320	13,848	10,824-10,866	95	36°	99	23
Dunn 8095 2784	08-11-81	Shell Oil Co. Packineau #12-17 SWNW Sec. 17-149-93	Mandaree-Bakken	320	15,225	10,795-10,805	35	42.3°	780	33
Dunn 8448 2458	03-04-82	Samedan Oil Corp. Lost Bridge State #1-16 NENE Sec. 16-148-96	Lost Bridge-Bakken	320	11,801	10,949-11,070	10	42°	-	0
Dunn 9402 2895	06-29-82	Amoco Production Co. Kupper Amoco "A" #1 SWNW Sec. 15-146-95	Chimney Butte-Duperow	320	14,025	11,476-11,502	71	42.3°	1,352	77
Dunn 8709 3074	08-10-82	Shell Oil Co. Burbank BIA #23-8 NESW Sec. 8-14793	Moccasin Creek-Bakken	320	14,430	10,516-10,624	34	39.7°	382	26
Dunn 9502 2987	10-01-82	Crawford Energy, Inc. Kovaloff #1 NESE Sec. 13-144-96	Murphy Creek-Bakken	160	13,812	10,806-10,864	34	37.3°	571	5
Golden Valley 8959 2772	03-24-82	Al-Aquitaine Expl., LTD. Jones Ranch #14-34 SESW Sec. 34-143-104	Pearl-Duperow	320	12,550	10,937-10,945	30	26.9°	1,000	0
Golden Valley 8324 2897	08-13-82	Gulf Oil Corp. Barkland #1-18-2A NWNE Sec. 18-142-104	Bonnie View-Red River	320	12,440	12,335-12,381	109	28.1°	750	4
McKenzie 9006 2709	01-28-81	The Superior Oil Co. Barrows #1 SESE Sec. 23-152-100	Elk-Interlake	320	14,200	13,234-13,262	439	45.5°	994	21
McKenzie 9037 2714	02-04-82	Amarex Inc. Fettig #1 SESE Sec. 21-149-94	Squaw Creek-Red River	320	14,501	14,141-14,155	346	50°	1,500	3
McKenzie 9138 2797	02-25-82	W.H.H.T.E. Holler #1 SWSE Sec. 22-146-98	Ranch Coulee-Red River	640	14,200	13,880-13,888	19*	52.1°	51,579	75

County, File No., Order No.	Comp. Date	Operator, Well, Location	Field, Pool	Spacing	Total Depth	Interval Perforated	Initial Production (Bbls. Oil)	Gravity	GOR	Water %
McKenzie 8340 2717	02-08-82	Belco Petroleum Corp. Edgar BN #11-13 SENE Sec. 13-145-101	Rough Rider-Red River	320	13,270	13,016-13,092	189	52°	5,862	17
McKenzie 9005 2779	02-05-82	Gulf Oil Corp. Federal #1-21-3D SWSE Sec. 21-145-100	Rhoades-Red River	320	13,924	13,311-13,319	63*	-	27,619	23
McKenzie 8726 2786	01-19-83	Patrick Petroleum Corp. Lind #1-12 SESE Sec. 12-145-98	Little Knife-Red River	320	13,920	13,766-13,832	182*	55°	15,735	11
McKenzie 9034 2887	01-02-82	Tom Brown, Inc. Melland #29-6 SENW Sec. 29-150-104	Estes-Madison	160	9,367	9,043- 9,156	32	38°	1,875	89
McKenzie 8322 2734	03-21-82	HNG Oil Co. Link #34-1 SWSE Sec. 34-151-102	Nameless-Silurian	320	13,700	13,163-13,191	340	52°	2,588	0
McKenzie 9180 2799	03-22-82	Pogo Producing Co. Johnsrud #1-3 SESE Sec. 3-149-98	Pembroke-Red River	320	14,432	14,284-14,395	58*	61.5°	39,199	0
McKenzie 8933 2769	03-13-82	Flying J Expl. & Prod. Co. State #13-26 SWSW Sec. 26-150-97	North Fork-Silurian	320	13,760	13,558-13,568	120	56°	3,942	32
McKenzie 7997 2783	03-02-82	Amoco Prod. Co. Mork #1 NESW Sec. 8-149-99	Pleasant Hill-Red River	320	14,200	14,006-14,056	182*	54.8°	35,819	25
McKenzie 8985 2775	04-10-82	Ladd Petroleum Corp. Paulson #24-43 NESE Sec. 24-151-104	Assiniboine-Red River	160	13,300	13,098-13,182	2,359*	45°	890	0
McKenzie 8737 2765	04-01-82	Abraxas Petroleum Corp. Burning Mine Butte #4-33 NWSE Sec. 4-147-102	Burning Mine-Red River	320	14,005	13,216-13,228	282	50.1°	3,400	22
McKenzie 9309 2813	04-30-82	Gulf Oil Corp. Lindvig #1-11-3C SESE Sec. 11-153-101	Baker-Madison	160	13,800	9,429- 9,439	107	33.2°	486	0
McKenzie 9163 2792	03-29-82	Puma Petroleum Co. Paschke #2-18 NENW Sec. 18-149-103	Winter Butte-Red River	320	13,020	12,856-12,866	427	48°	1,390	1
McKenzie 8481 3073	03-24-82	Shell Oil Co. BN #33-7 NWSE Sec. 7-146-103	Poker Jim-Bakken	320	11,317	10,646-10,660	7	36.5°	429	77
McKenzie 8717 2809	05-20-82	SunBehm Gas, Inc. Chitwood #32-7 SWNE Sec. 32-149-101	Sather Lake-Madison	160	13,765	9,472- 9,484	15	41.7°	1,824	89
McKenzie 8898 2792	04-17-82	Puma Petroleum Co. Amerada State #1-16 NENW Sec. 16-149-103	Winter Butte-Devonian	320	11,617	11,162-11,240	127	38.5°	1,158	449
McKenzie 9363 2852	05-14-82	Amatex, Inc. Becken #1 NENE Sec. 7-151-97	Elidah-Red River	320	14,654	14,411-14,465	16*	55°	75,000	90
McKenzie 9004 2851	05-19-82	Exxon Corp. Fleck #1 NESE Sec. 10-150-100	Farland-Red River	320	15,000	14,066-14,092	80	51.6°	5,625	20

County, File No., Order No.	Comp. Date	Operator, Well, Location	Field, Pool	Spacing	Total Depth	Interval Perforated	Initial Production (Bbls. Oil)	Gravity	GOR	Water %
McKenzie 8945 2866	05-27-82	Al-Aquitaine Explo., LTD. Hovde #1-6 NENE Sec. 6-150-100	Spring Creek-Silurian	320	14,000	13,451-13,464	380	49.5°	1,400	3
McKenzie 8935 2874	12-13-82	Ranger Oil Co. Rolfsrud #11-17 NESW Sec. 17-152-96	Westberg-Birdbear	160	14,140	10,918-10,924	42	42.1°	3,310	88
McKenzie 8400 2858	05-12-82	Pennzoil Expl. & Prod. Co. BN Six Creek #27-13 NWSW Sec. 27-145-102	Six Creek-Red River	320	12,922	12,688-12,701	72	40°	417	48
McKenzie 9252 2859	05-08-82	Pennzoil Expl. & Prod. Co. BN Riverside #25-32 SWNE Sec. 25-146-102	Riverside-Red River	320	13,265	13,104-13,136	866	50.4°	1,519	21
McKenzie 8883 2860	04-25-82	Pennzoil Expl. & Prod. Co. BN Bowline Creek #35-24 SESW Sec. 35-144-102	North Branch-Red River	320	13,427	13,292-13,310	659	49.8°	1,704	0
McKenzie 9470 2855	06-11-82	Aminoil USA, Inc. Nelson #1-7X NENE Sec. 7-148-100	Buffalo Wallow-Red River	320	13,906	13,754-13,764	319*	54.6°	11,325	0
McKenzie 9318 2836	06-18-82	Universal Resources Corp. T. K. #1 SENE Sec. 30-153-95	Keene-Silurian	160	13,157	11,940-11,946	575	50°	1,804	0
McKenzie 7167 2936	06-19-82	Pennzoil Expl. & Prod. Co. Little Tank BN #19-21 NENW Sec. 19-148-101	Little Tank-Red River	320	13,650	13,470-13,514	557	54.1°	2,200	8
McKenzie 8604 2937	06-16-82	Pennzoil Trailside #3-21 NENW Sec. 3-146-100	Trailside-Duperow	320	13,514	11,355-11,361	116	44.2°	458	34
McKenzie 9334 2869	07-07-82	Broschat Engr./Jorguss Oil Kirkland #1 NENW Sec. 12-149-96	Croff-Red River	320	14,288	14,116-14,162	192*	54°	10,900	0
McKenzie 8187 2896	10-03-81	W.H.H.T.E. Lyvoid Larson #1 NWNE Sec. 10-148-101	Bear Butte-Birdbear	320	15,059	11,348-11,352	15	44.3°	1,125	83
McKenzie 9504 2880	08-12-82	The Superior Oil Co. Stepanek et al #1 E/2 NW Sec. 28-152-101	Camp-Silurian	320	13,890	13,286-13,304	182	45.7°	1,100	40
McKenzie 9403 2939	08-20-82	Sun Expl. & Prod. Co. Erickson #1-27 NWSE Sec. 27-152-103	Glass Bluff-Madison	160	13,600	9,244- 9,266	97	38.1°	-	17
McKenzie 8963 2804	09-13-82	Pogo Producing Co. Schmidtz #1-9 NWSW Sec. 9-152-101	Camp-Red River	320	13,825	13,588-13,624	58	N/A	1,103	46
McKenzie 9507 2963	09-02-82	The Superior Oil Co. Nelson et al #2 SWSE Sec. 1-152-100	Indian Hill-Silurian	320	13,850	13,168-13,271	346	45.1°	-	60
McKenzie 9617 2957	09-21-82	SunBehm Gas, Inc. Bolken #24-12 NWSW Sec. 24-151-101	Alexander-Madison	160	13,846	9,474- 9,484	174	41°	1,084	36
McKenzie 9668 2967	09-24-82	Tom Brown, Inc. Bratcher State #10-24 SESW Sec. 10-151-101	Ragged Butte-Madison	160	13,750	9,384- 9,392	230	39°	1,200	19

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County, File No., Order No.	Comp. Date	Operator, Well, Location	Field, Pool	Spacing	Total Depth	Interval Perforated	Initial Production (Bbls. Oil)	Gravity	GOR	Water %
McKenzie 7932 2982	09-22-82	Exxon Corp. State of North Dakota #1 SWSE Sec. 36-152-102	Sioux-Madison	160	13,800	9,414- 9,421	53	39.2°	TSTM	25
McKenzie 6501 2994	09-24-82	Gulf Oil Corp. Eckert Foundation #1 NESE Sec. 6-152-101	Indian Hill-Madison	160	13,985	9,462- 9,468	305	37.1°	426	1
McKenzie 9669 3013	10-06-82	W.H.H.T.E. Brockmeier #2 SWNE Sec. 1-146-98	Mary-Red River	640	14,170	13,996-14,006	20*	60°	133,366	30
McKenzie 9470 2999	06-11-82	Aminoil USA, Inc. Nelson #1-7X NENE Sec. 7-148-100	Buffalo Wallow-Duperow	320	13,906	11,610-11,618	408	54.6°	11,325	17
McKenzie 9593 3052	10-20-82	The Superior Oil Co. Nelson "A" #1 SESW Sec. 29-152-101	Camp-Madison	160	13,900	9,320-10,009	25	38.2°	1,570	82
McKenzie 9519 3028	11-09-82	Tenneco Oil Co. Tank #1-3 NWSE Sec. 3-150-96	Johnson Corner-Bakken	160	14,163	10,786-10,812	206	50°	1,334	2
McKenzie 9689 3055	11-21-82	Edwin L. & Berry R. Cox Bertinuson #11-30 NWNW Sec. 30-151-100	Patent Gate-Duperow	320	14,025	11,578-11,589	628	43°	1,911	2
McKenzie 8992 3072	11-24-82	Shell Oil Co. USA #11-4-76 NWNW Sec. 4-149-104	Estes-Bakken	320	12,935	10,375-10,450	13	-	308	73
McKenzie 9662 3085	11-17-82	Texaco, Inc. L. M. Stenehjem #1 SENW Sec. 10-151-100	Poe-Madison	-	14,200	9,676- 9,684	-	39°	1,414	-
McKenzie 8314 -	12-01-82	Shell Oil Co. USA #42-8 SENE Sec. 8-147-103	MonDak-Bakken	-	14,430	10,544-10,614	14	39.7°	1,714	88
McKenzie 8935 3034	12-13-82	Ranger Oil Co. Rolfsrud #11-17 NESW Sec. 17-152-96	Westberg-Bakken	160	14,140	10,620-10,656	99	42.1°	1,535	27
McKenzie 9755 -	12-17-82	Sun Exploration Co. D. M. Iverson #1-31 SESW Sec. 31-152-102	Wildcat-Madison	-	13,700	9,454- 9,481	232	37°	435	5
McKenzie 8399 3087	12-28-82	SunBehm Gas, Inc. Nygaard #1-29 NENW Sec. 29-150-101	Pronghorn-Duperow	320	13,870	11,582-11,602	25	43.8°	TSTM	17
McKenzie 9635 2988	10-06-82	Placid Oil Co. Eide #35-11 NESW Sec. 35-149-99	Juniper-Red River	320	14,350	14,200-14,234	20*	62.6°	60,000	50
Mountrail 9098 2678	02-25-82	Nortex Gas & Oil Co. KOK #1-13 SWNW Sec. 13-152-88	Wabek-Madison	160	7,545	7,340- 7,346	11	33°	100	82
Mountrail 8689 2873	07-06-82	Ranger Oil Co. Rice #14-3 SESW Sec. 3-158-94	Powers Lake-Madison	160	13,295	8,236- 8,306	13	46.6°	TSTM	92
Slope 9209 2758	03-14-82	Anadarko Prod., Co. Cash Creek Federal "A" #1 SESW Sec. 14-135-106	Cash-Red River	320	10,164 DTD 10,097 LTD	9,948- 9,957	162	35.3°	271	0

County, File No., Order No.	Comp. Date	Operator, Well, Location	Field, Pool	Spacing	Total Depth	Interval Perforated	Initial Production (Bbls. Oil)	Gravity	GOR	Water %
Stark 9322 2743	shut-in	William C. Kirkwood Kostelecky #44-29 SESE Sec. 29-139-96	Dobson Butte-Red River	320	12,756	-	-	-	-	-
Stark 9056 2675	01-05-82	Gulf Oil Corp. Ogre #1-24-1C SENW Sec. 24-139-93	Taylor-Winnipeg-Deadwood	640	11,928	11,768-11,784	120*	57.9°	25,000	0
Stark 9322 2743	07-31-82	William C. Kirkwood Kostelecky #44-29 SESE Sec. 29-139-96	Dobson Butte-Silurian	320	12,756	11,018-11,054	383	41.4°	610	59
Stark 9422 2935	07-22-82	Union Texas Petr. Corp. Kuntz #9-1 SENE Sec. 9-140-98	New Hradec-Red River	320	12,779	12,541-12,563	89	49.1°	2,169	13
Stark 9706 2934	08-27-82	Southport Expl., Inc. Decker #1-32 NWSW Sec. 32-140-99	Bell-Tyler	160	9,500	8,192- 8,202	571	35.6°	212	0
Williams 8910 2732	01-28-82	Texaco, Inc. T. P. Slette NCT #1 NWNW Sec. 13-153-100	Willow Creek-Red River	320	14,200	14,037-14,051	423	52.6°	6,619	15
Williams 9100 2676	01-22-82	Texas Gas Expl., Corp. Esterby #1-11 NWSW Sec. 11-159-100	Green Lake-Madison	160	12,825	8,148- 8,165	232	29.3°	107	0
Williams 8964 2756	02-16-82	National Oil Co. Gohrick #43-17 NESE Sec. 17-158-95	McGregor-Bakken	320	10,864 LOG	9,555- 9,574	75	40.4°	26	4
Williams 8731 2654	05-27-82	Pogo Producing Co. Anderson #1-27 SWNE Sec. 27-154-103	Painted Woods-Winnipegosis	320	13,380	11,928-11,992	61	30°	TSTM	22
Williams 8998 2789	03-16-82	Everett Drlg Ventures Inc. Long Creek #4 NWNE Sec. 1-153-99	Long Creek-Red River	320	14,591	14,312-14,328	217	53.7°	4,871	0
Williams 9067 2771	03-26-82	Ranger Oil Co. Toftness #9-8 NESE Sec. 8-159-95	Sauk-Bakken	320	10,185	9,236- 9,282	28	41.6°	TSTM	0
Williams 8645 2702	04-15-82	Donald C. Slawson Moe #2-1 NWSW Sec. 2-156-96	West Bank-Lodgepole-Bakken	160	13,400	9,630- 9,900	28	35°	1,920	50
Williams 8867 2857	04-23-82	Sun Exploration & Prod. Co. Horob #1-15 SWNE Sec. 15-155-104	Hegron-Madison	160	9,800	9,080- 9,676	6	35°	TSTM	82
Williams 9207 2814	05-01-82	Ranger Oil Co. McGinnity #14-6 SESW Sec. 6-158-95	Temple-Silurian	320	12,780	12,144-12,258	296	47.4°	1,303	15
Williams 9417 2811	06-11-82	Lousiana Land & Expl. Co. Bratlien 41-33 #1 NENE Sec. 33-154-100	Last Chance-Madison	160	14,100	9,494- 9,521	81	37.6°	1,116	18
Williams 9361 2856	06-23-82	Northwest Expl. Co. Pederson #3 SWNE Sec. 18-158-95	Temple-Winnipegosis	320	12,980	11,174-11,184	296	46°	1,000	8
Williams 9206 2884	06-15-82	Universal Resources Corp. Bendixson #2-17 SWNW Sec. 17-157-101	Good Luck-Duperow	160	10,850	10,458-10,528	31	34°	806	76

County, File No., Order No.	Comp. Date	Operator, Well, Location	Field, Pool	Spacing	Total Depth	Interval Perforated	Initial Production (Bbls. Oil)	Gravity	GOR	Water %
Williams 9342 2898	07-08-82	Gulf Oil Corp. Skurdal #1-24-3B NESE Sec. 24-153-102	Hardscrabble-Red River	320	13,350	13,204-13,210	254	47°	1,035	0
Williams 9518 2926	07-29-82	Sun Expl. & Prod. Co. Johnsrud #1-3 NWNW Sec. 3-152-103	Eightmile-Madison	160	13,500	8,954- 8,972	232	38.1°	452	23
Williams 7079 3057	10-28-82	Mosbacher Prod. Co. Earl Hefflefinger #3-1 NWNW Sec. 3-154-100	Williston-Duperow	160	14,000	11,484-11,494	60	37°	980	27
Williams 7903 3039	11-06-82	W.H.H.T.E. Cunningham #1 SWSW Sec. 23-157-100	Marmon-Dawson Bay	320	13,400	11,258-11,266	48	47°	625	16

Table 2. NORTH DAKOTA OIL & GAS DISCOVERIES IN 1982

New Pool Discoveries for Each County

Billings County

Madison	3
Bakken	3
Duperow	6
Red River	3
Total	15

Bottineau County

Madison	1
Total	1

Bowman County

Red River	1
Total	1

Burke County

Madison	1
Total	1

Divide County

Red River	3
Total	3

Dunn County

Bakken	4
Duperow	3
Red River	1
Total	8

Golden Valley County

Duperow	1
Red River	1
Total	2

McKenzie County

Madison	11
Bakken	5
Birdbear	2
Duperow	4
Devonian	1
Silurian	7
Red River	21
Total	51

Mountrail County

Madison	2
Total	2

Slope County

Red River	1
Total	1

Stark County

Tyler	1
Silurian	1
Red River	2
Winnipeg/ Deadwood	1
Total	5

Williams County

Madison	4
Lodgepole/ Bakken	1
Bakken	2
Duperow	2
Dawson Bay	1
Winnipegosis	2
Silurian	1
Red River	3
Total	16

Discoveries in Each Formation

Pennsylvanian	
Tyler	1
Mississippian	
Madison	22
Lodgepole/ Bakken	1
Bakken	14
Devonian	
Birdbear	2
Duperow	16
Dawson Bay	1
Winnipegosis	2
Undifferentiated	1
Silurian	9
Ordovician	
Red River	36
Winnipeg/ Deadwood	1

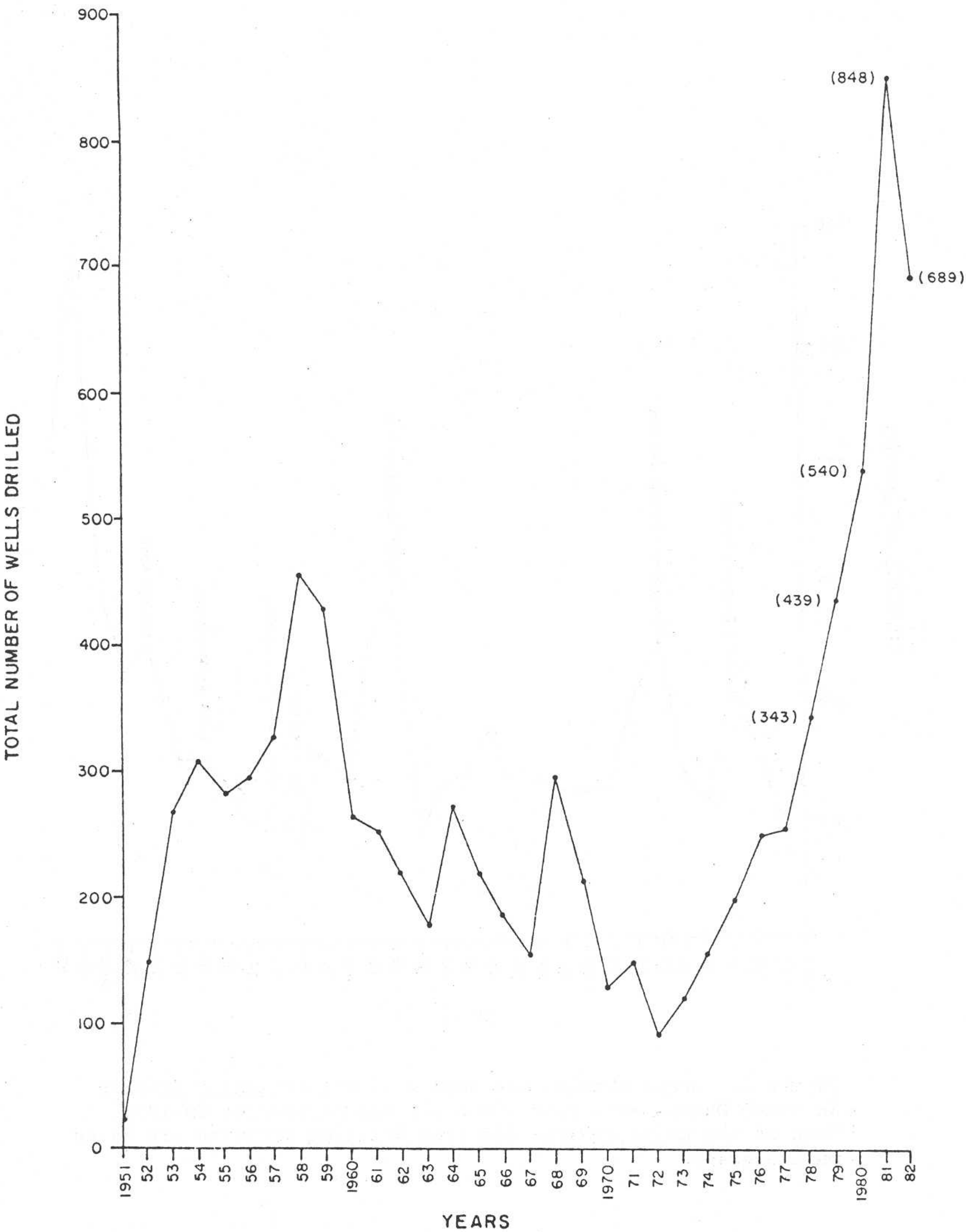


Figure 1. Graph showing the number of wells drilled in North Dakota each year since oil was discovered in 1951. Total includes both exploratory and development wells.

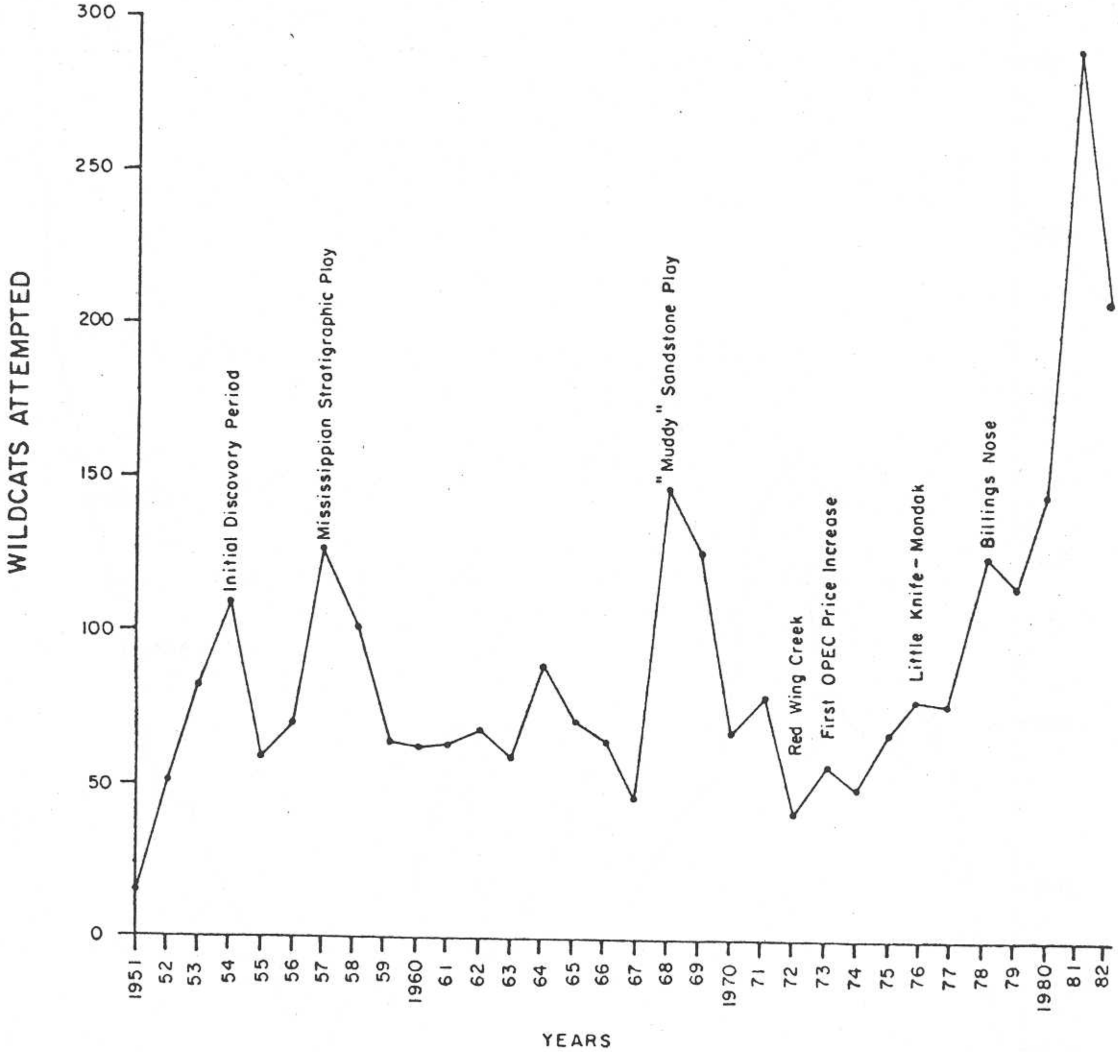


Figure 2. Graph showing the number of wildcat wells drilled in North Dakota each year since oil was discovered in 1951. Some of the major events affecting drilling activity are noted on the graph.

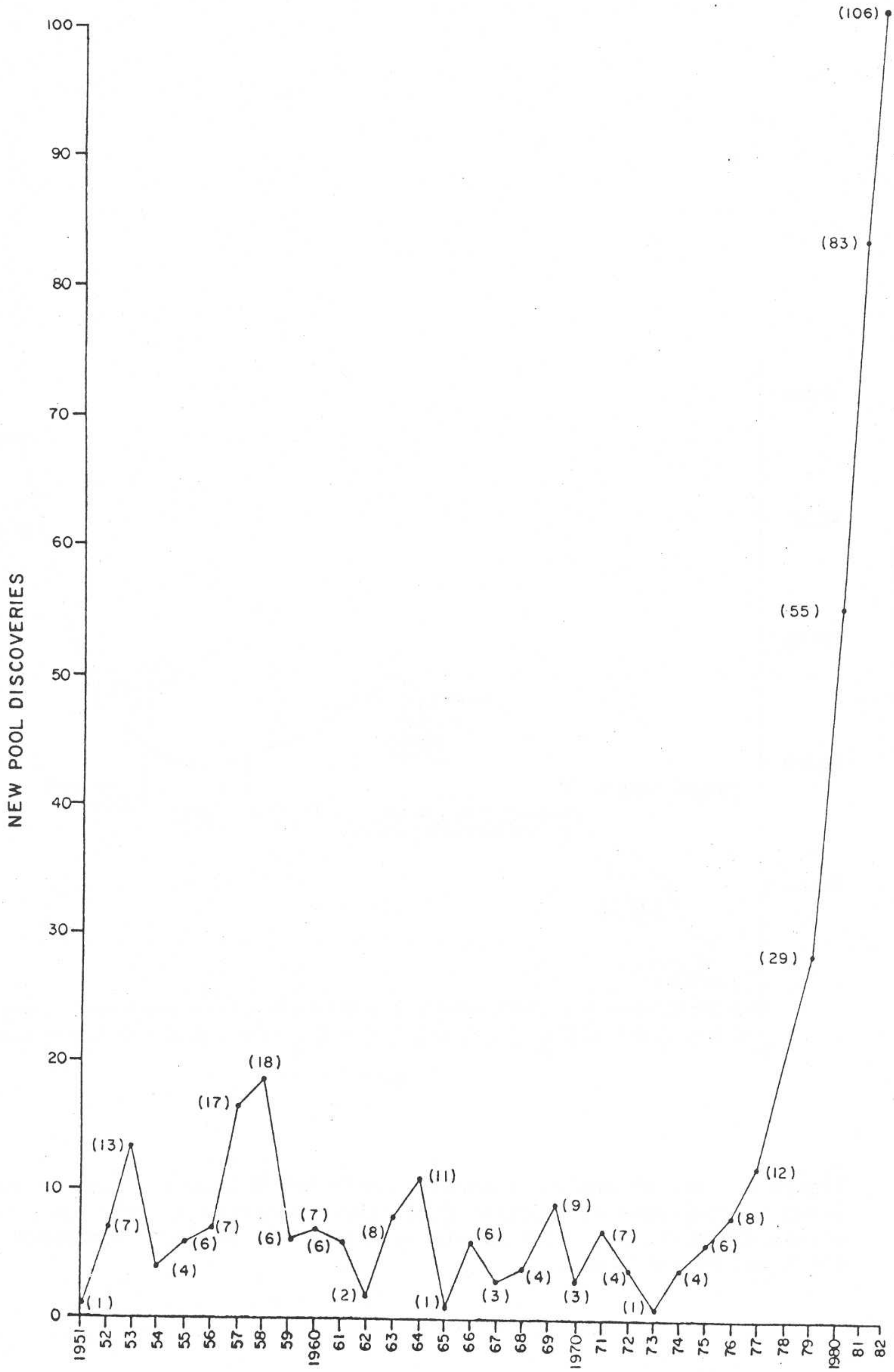


Figure 3. Graph showing the number of new pools discovered each year in North Dakota. The total number of pools discovered each year since 1978 has been much higher than in previous years.

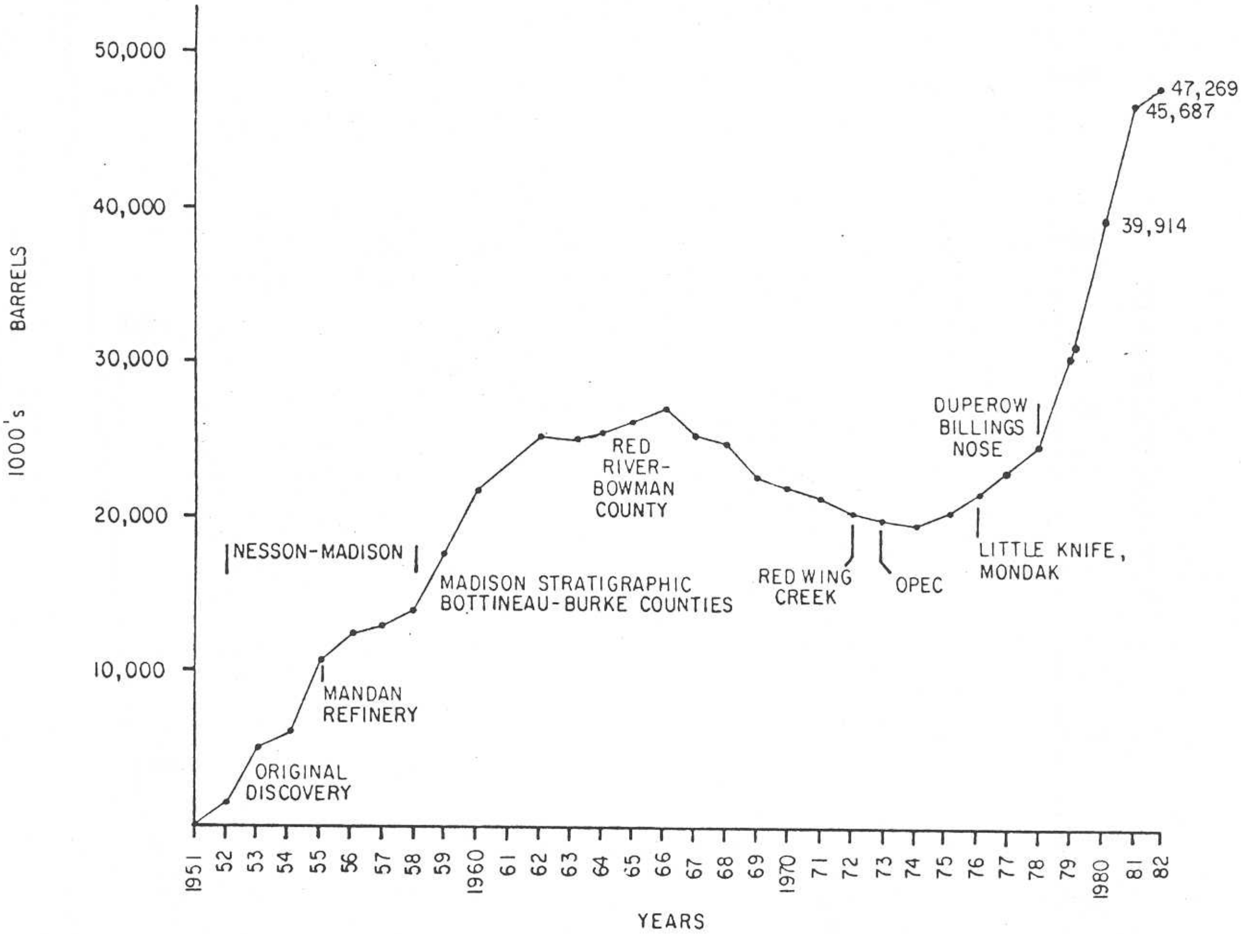


Figure 4. Annual crude oil production in North Dakota. Figures are given in thousands of barrels; thus, the production in 1982 was 47,269,000 barrels. Major events affecting oil production history are noted on the graph.

THE NON-FUEL MINERAL INDUSTRY IN NORTH DAKOTA IN 1982

According to a statement from the U.S. Bureau of Mines, North Dakota's non-fuel mineral production in 1982 was valued at $16.3 million, a decrease of 28 percent from the previous year. Nationally, North Dakota ranked 48th among the states in value of total non-fuel mineral production. During the year, six nonmetallic mineral commodities were produced. No gains in output quantities over 1981 were recorded for any minerals and only clay registered a slight increase in production value. Sand and gravel was the leading commodity in terms of value, accounting for approximately 68 percent of the state total, followed by salt, lime, clay, peat, and gem stones, respectively.

PETROLEUM ENGINEERING LABORATORY

--Marvin Rygh

This summer, the NDGS is working with the University of North Dakota geology department in expanding the geological engineering curriculum by creating a petroleum engineering laboratory. The lab, which is still in the initial planning stages, will serve two purposes: it will supply "hands-on" experience for the engineering students and it will provide research facilities to supplement studies being done in the geology department and the Survey.

At the onset, equipment will be installed to test drilling fluid properties and determine porosities and permeabilities of core samples. In the near future, we plan to install an apparatus to determine formation damage resulting from injection of various fluids such as drilling mud or acid solutions.

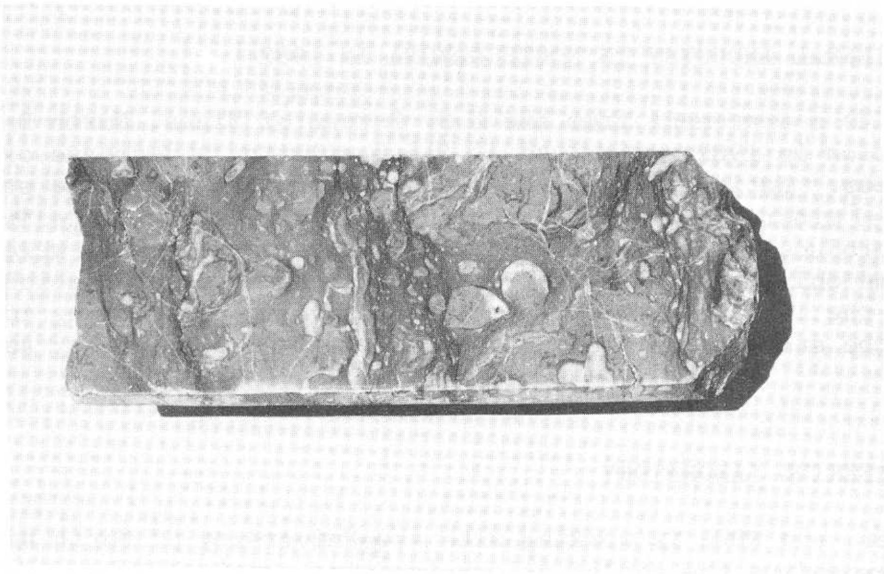
The facilities in this laboratory will enhance research projects by enabling us to quantify data rather than estimating it. Further, a turn toward a more technical curriculum will better prepare engineering students for employment in the oil industry. We expect this lab to be useful to the students as well as a valuable asset to the research being done in the Survey and the geology department.

WHY DO WE SAVE ALL THOSE ROCKS?

--Rod Stoa

Visitors to the Wilson M. Laird Core and Sample Library sometimes ask why we save so many rocks. There are several reasons for saving these rocks, but the main reason for maintaining the collection is to provide an aid in the exploration for new petroleum resources. By examining the well cores here at the Survey, visiting petroleum geologists and other researchers are able to learn a lot about the geology of areas where hydrocarbons occur. Studying well cores enables the geologist to determine the type of environment that existed when the rocks were deposited. Fossils in the cores, composition of the rock, the presence or absence of traces of oil--all of these help the geologist build a sound data base for further exploration activities. This information, coupled with other tools of exploration such as seismic surveys, electric well logs, and various types of maps, enables the geologist to thoroughly evaluate prospective exploration sites.

Another aspect of oil exploration is that, like sheep, oil companies have a herd instinct and tend to follow one another. When one operator finds something exciting, it isn't long until a crowd gathers to see what is happening. Discovery wells tend to fuel the fires of exploration, resulting in more wells being drilled and, consequently, more discoveries.



Polished slab of core from the Socony Vacuum Oil Co. Pegasus Div. Solomon Birdbear well, located in section 22, T149N, R91W, Dunn County, North Dakota. This core is of the Devonian Birdbear Formation at a depth of approximately 10,370 feet.

Core materials, particularly those from producing reservoirs, are extremely important in devising secondary and tertiary recovery projects. In attempting to recover more oil from the rocks after the initial production in an oil field has declined to a relatively low level, operators often use various methods to increase production. Undertaking any work like this without seeing the actual rocks is little more than a guessing game. However, by studying the available core and studying the response of the rocks to various treatment methods, reservoir engineers are better able to decide how to stimulate production. When secondary recovery methods are successful, a higher percentage of oil can be recovered, resulting in more effective conservation of our mineral resources.

The simple fact that the state stands to gain a substantial amount of tax revenue if oil companies are successful in finding hydrocarbons is an important reason for properly maintaining the core collection. Geologists obtain various types of information by studying the rocks in our Core and Sample Library and this information is often the factor that determines whether a test hole is or is not drilled. If a decision to drill a well is made, and if the well is successful, producing perhaps 100 barrels of oil a day, the direct revenue to the State of North Dakota in taxes from that single well will exceed $100,000 a year (assuming oil is worth $28 a barrel). On his share of that same oil, the mineral owner will pay another $6,000 in direct taxes to the state and he will also pay taxes on the income from the well. The income both the oil company and the mineral owner receive from the well will result in considerable money circulating through the community and state. Conversely, when studies of cores show that a non-producing well would result from an exploration attempt, that decision not to drill will save an oil company a great deal of money because a well, whether it is productive or not, can cost at least a million dollars to drill in North Dakota.

State regulations require that cores and samples collected by the oil companies be sent to the State Geologist when he requests them. Over the years, compliance with this regulation has been excellent. In fact, North Dakota probably has the best collection of subsurface geologic material of any state in the United States. The oil and gas industry has invested at least $700,000,000 in collecting the core stored in the Wilson M. Laird Core and Sample Library. These materials need to be saved and maintained for the benefit of everyone.

REPRESENTATIVE CORE COLLECTION BEING COMPILED

--Rod Stoa

Several geologic formations reach their maximum thickness in the North Dakota portion of the Williston Basin. Since many of these formations are not exposed anywhere in the state, they are known only from the information obtained from test holes and wells that have been drilled through them. Many of the test holes were cored and the rock obtained during the coring process is now stored in the Wilson M. Laird Core and Sample Library here at the North Dakota Geological Survey.

A project of assembling core samples from various formations into an archival collection is currently underway. Core materials from these formations, many of which either produce or trap oil and gas, will be carefully assembled and oriented. They will then be slabbed (sawed lengthwise), and a polished surface will be put on one-half of the slabs. Detailed descriptions of the core materials for each formation and photographic records will be compiled for each of them. The collection will then be set aside and will be available for visual inspection as a reference set of core so that researchers will be able to see what a typical example of the formation from the North Dakota Williston Basin looks like. We expect to publish the descriptions and photographs when the project is completed.

APPLICATION OF ANALYTICAL EQUIPMENT TO THE NATURAL RESOURCES OF NORTH DAKOTA

--Dave Brekke

The evaluation of mineral resources involves many different approaches to completely describe and understand the resource being studied. Some of these include locating, mapping, and inventorying the resource; characterizing or describing the resource; anticipating problems in the use of the resource; and protecting and preventing waste of the resource. Characterization and description is accomplished by observing the physical and chemical properties by utilizing various kinds of analytical tools. Depending on the observations or information required, these tools can be as simple as a hand lens or magnifying glass, or as complex as an electron microscrope. The NDGS has access to several advanced instruments such as a scanning electron microscope/ microprobe, an x-ray fluorescence spectrometer, and an x-ray diffractometer. These instruments allow detailed examination of mineral resources and they enable our staff to characterize the resources and help anticipate problems in their use. Rocks can be analyzed for both their chemical and mineral content.

The scanning electron microscope uses a very narrow beam of electrons to produce an image of the sample somewhat like a television picture. This image can be magnified up to 180,000 times, allowing us to observe the tiny particles that make up a rock and see how it is put together. The electron microscope is used in a variety of ways. For example, it enables us to see the actual pore spaces in a sample of an oil reservoir rock and determine whether problems will develop when attempts are made to stimulate a well to produce more oil by the use of chemical fluids. The other part of the instrument is a microprobe system, which can obtain information on the chemistry of each particle. Anything that can be seen in the electron microscope can also be chemically analyzed. An example of an application of this device would be to find out exactly which minerals are mixed with lignite and thereby determine which contaminants might cause boiler fouling problems in power plants.

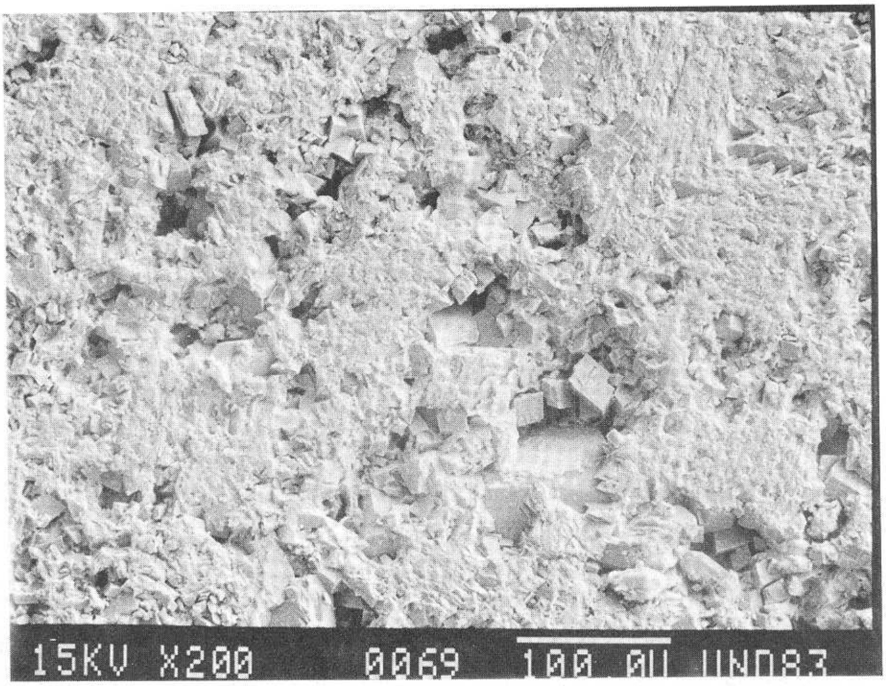
Figures 1 and 2 are scanning electron microscope photomicrographs of two reservoir rocks from the Williston Basin. The length of the bar scale is 100 micrometers or 0.0039 inches. Figure 1 shows a sandstone with good interconnected porosity, even though crystals of calcite are present in the pore spaces. This rock would make a good oil reservoir. Figure 2 shows a limestone with large pore spaces that are almost completely filled with crystals of calcite. This rock is mainly very fine-grained limestone with low porosity. Anhydrite crystals probably fill any pore spaces that would otherwise be present. This rock would make a poor oil reservoir.

The x-ray fluorescence spectrometer uses a wide beam of x rays to bombard a sample of ground-up rock or other material. This causes the sample to emit its own x rays and these x rays which the sample emits characterize the chemical elements found in the sample. The x-ray fluorescence spectrometer can be used to determine the average chemical composition of a large sample. The instrument is capable of determining the concentration of most elements down to a range of 10 to 100 parts per million. An example of an application would be to evaluate the grade of some of North Dakota's non-metallic ore deposits such as potash.

The x-ray diffractometer uses a narrow beam of x rays to determine the crystal structure or the arrangement of atoms in a substance or mixture of substances. Using this instrument, it is possible to identify mineral particles in a rock even when the particles are too small to see with the unaided eye. One of the major applications of this device is to classify rocks and sediments according to their mineral content.

The Survey also has other equipment such as optical microscopes, sieving apparatus, and rock saws that aid in the characterization of rocks and sediments. Field equipment to aid on-site evaluation include surveying tools, various water property instruments, a logging truck capable of recording a variety of different types of wire-line logs, an auger drill, and soil probes.

In summary, the NDGS has access to a wide range of analytical instruments capable of solving a variety of geologic questions and problems. Our equipment provides the researcher with powerful tools of investigation when evaluating natural resources.



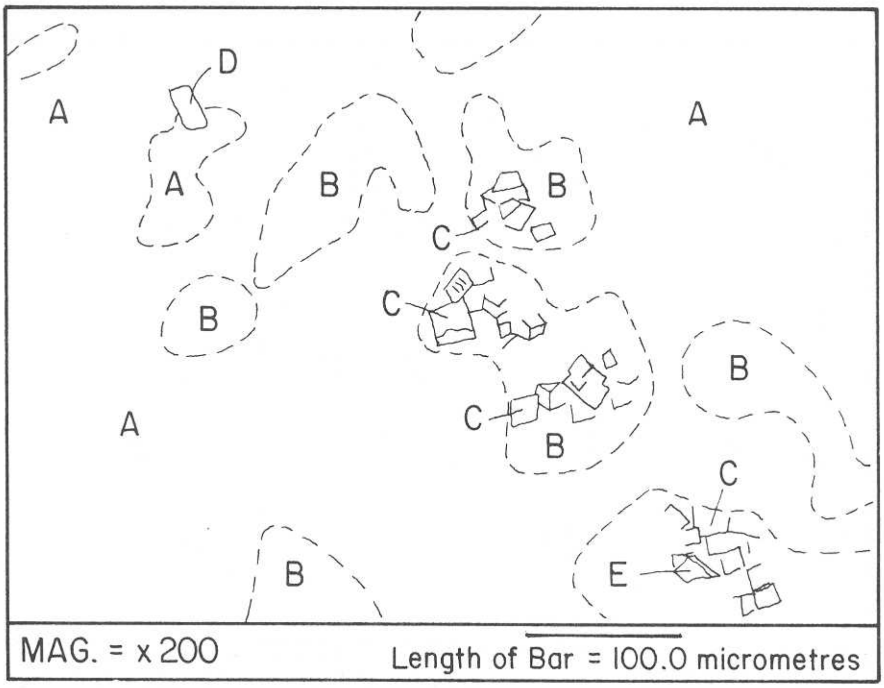
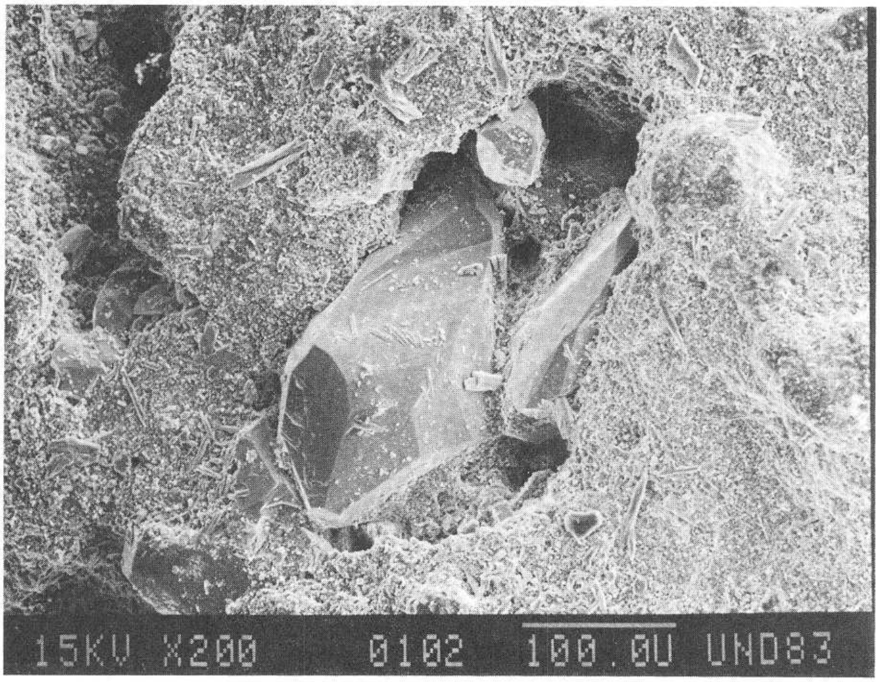


Figure 1. Scanning Electron Microscope (SEM) photomicrograph of the Spearfish Formation. Magnification is 200 times.

A. Silty sandstone
B. Pore spaces
C. Calcite crystals
D. Plagioclase feldspar
E. Quartz



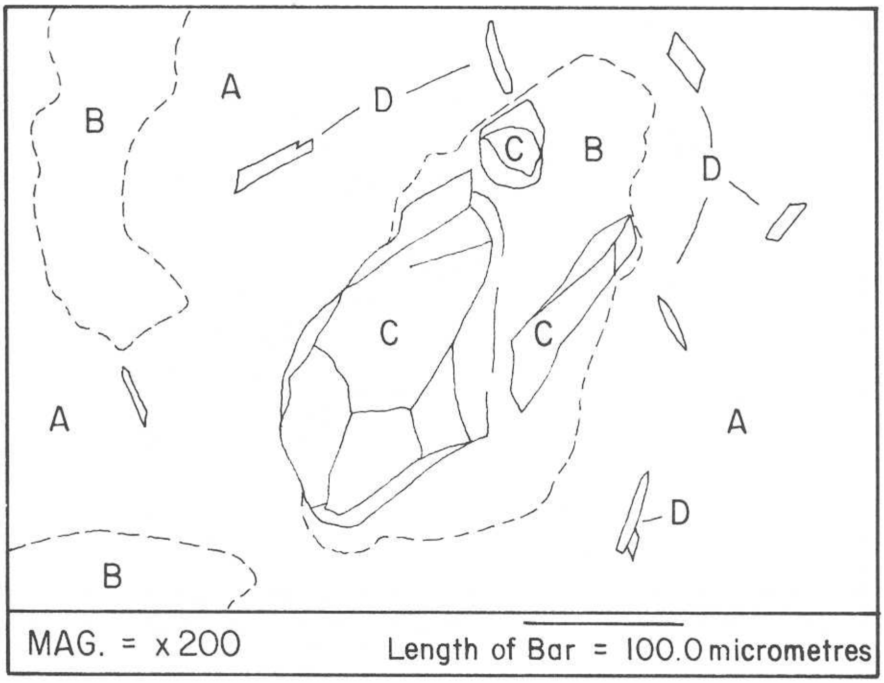


Figure 2. SEM photomicrograph of a Madison Group limestone Magnification is 200 times.

A. Limestone
B. Pore spaces
C. Calcite crystals
D. Anhydrite

THE ROLE OF THE NDGS IN THE STATE'S SOLID WASTE MANAGEMENT PROGRAM --John Hoganson

Six pounds of refuse are produced daily by every man, woman, and child in North America. It has been estimated that a city of one million people generates refuse with an annual volume equivalent to about 200 acres covered fifteen feet deep. Because of our consumptive way of life, we have a major problem in this country--what to do with our garbage. In partial recognition of this problem, the United States Environmental Protection Agency (EPA) was established in the early 1970s. Shortly thereafter the North Dakota Department of Health was commissioned to administer EPA regulations in the state. Solid waste management regulations and permitting procedure guidelines for disposal of wastes in North Dakota were established by the state legislature in 1976. Regulatory responsibility was given to the Health Department; the State Geological Survey and State Water Commission were mandated to provide technical support to the Health Department in assessing permit applications to construct and operate waste-disposal facilities in the state.

Before discussing the geologist's role in evaluating prospective waste-disposal sites, it is appropriate to define the categories of wastes generated in North Dakota and illustrate the standard engineering method in waste-disposal facility construction. Three major categories of solid wastes are produced in North Dakota: hazardous waste, putrescible waste, and special waste. Unlike many other states, hazardous waste disposal in North Dakota is not, at this time, a major concern because few hazardous waste generators exist in the state. North Dakota follows the EPA standards in defining hazardous waste. The definition is complex and at times rather nebulous. At least five criteria are used to determine whether waste should be characterized as hazardous: toxicity, ignitability, corrosiveness, reactivity, and quantity. Such things as pesticides, paints, solvents, etc. can fall into this category. Federal law specifies that all hazardous waste generators must identify themselves. There are 75 such entities, producing small amounts of hazardous wastes, in North Dakota. North Dakota, however, does not have a major hazardous waste disposal facility. Most such wastes are transported out-of-state to central receiving sites in Illinois and Idaho.

Putrescible wastes are solid wastes capable of being decomposed rapidly enough to cause nuisances from offensive odors or to produce fly-breeding conditions. Garbage is putrescible animal and vegetable wastes. The third category is called special waste. It is a catch-all category that includes non-putrescible and non-hazardous wastes such as construction or demolition material, bi-products from coal combustion in power plants (mostly flyash--1 3/4 million tons of this waste is produced annually in North Dakota), potato plant residues, etc.

What do we do with solid waste? Prior to 1976, solid waste in North Dakota was "disposed" of in open garbage burning dumps--a place where many of us practiced marksmanship by shooting rats. Today, we bury solid wastes in engineered disposal facilities called sanitary landfills (for putrescible wastes) or special-use landfills (for special wastes). This is where geological expertise comes into play. Although several different engineering methods are used in constructing and operating landfills in North Dakota, the most common is the trench and fill method (fig. 1). In the disposal procedure, a narrow trench is excavated and filled with solid waste. The waste is compacted to reduce its volume and covered with soil at the end of the day. The completed landfill is like a layer cake consisting of successive layers of earth and compacted refuse. The landfill method of solid waste disposal is the most economical technique for waste management used to minimize pollution of surface water, groundwater and air, not only in our state, but nation-wide. It has been estimated that more than 20,000 sanitary landfills are operating in North America and that these facilities accommodate more than 90% of the solid waste produced by municipal and industrial activities. North Dakota has 104 permitted sanitary landfills and about 40 permitted special-use landfills.

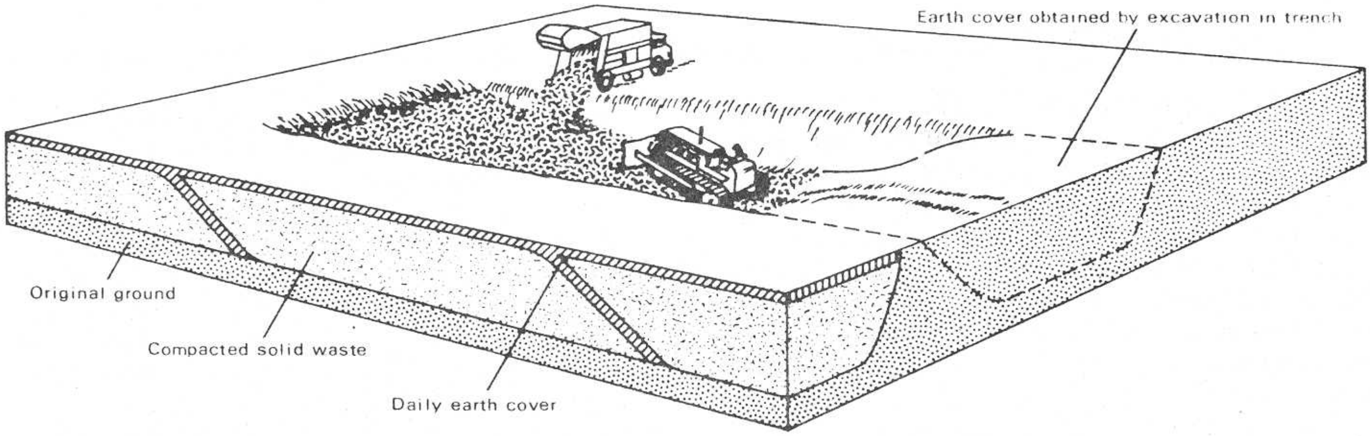


Figure 1. Trench method of landfilling (from Lewicke, 1972).

Problems do arise, however, when refuse is buried because almost all material is subject to leaching when it comes in contact with water. The liquid generated by this process, leachate, usually contains organic and/or inorganic contaminants and it is characteristically high in total dissolved solids. Leachate can be produced in two ways. Solid waste emplaced in a trench dug beneath the water table will react with the groundwater moving through it, producing leachate. On the other hand, if the material is placed in a trench above the water table leachate may be produced when meteoric water (precipitation, snowmelt) percolates through the soil-cover material and into the buried wastes. In either case, once leachate is produced and reaches the water table, it will migrate laterally in the direction of groundwater flow. The danger of groundwater contamination is the primary geological problem associated with the landfill method of solid waste disposal. Proper engineering in construction and operation of a landfill can essentially eliminate the potential pollution of surface waters and the atmosphere.

The problem of groundwater contamination becomes more acute when one considers that leachate can be produced long after a disposal facility is closed. In fact, landfills can produce leachates for many decades after closure. Little is known, however, about the potential of leachate production over very long periods of time, although studies have shown that leachate is still being generated from rudimentary landfills used during the days of the Roman Empire. Once pollutants begin moving through the groundwater flow system, a solution to the problem may be impossible, or at least difficult and expensive. The aquifer or part of the aquifer affected may be damaged beyond repair. Detection of groundwater contamination is difficult and expensive. In fact, pollution is usually identified only after a water well has been contaminated. For this reason, it is the responsibility of the State Department of Health with advice from the State Water Commission and the NDGS, to be certain that solid wastes are disposed of in landfill facilities located in areas where the damage that may occur to the state's water resources will be minimal. This is accomplished through a coordinated effort between the three agencies in the evaluation of permit applications to construct and operate landfills.

It is the mandated responsibility of the NDGS to evaluate permit applications from geological and hydrogeological perspectives. In evaluating an area as a prospective site for a waste disposal facility, the geologist should know as much as possible about the geological and hydrogeological conditions in the vicinity of the proposed site. Unfortunately our knowledge of all the parameters that this entails falls short of the ideal and varies considerably from place to place in the state. Briefly, the following factors are taken into consideration in evaluating prospective sites.

Geomorphology and topography

The major concern with respect to surface water contamination is erosion of the cover material exposing wastes to meteoric waters resulting in leachate production. Once the wastes are exposed, leachate or for that matter the refuse itself, can easily be transported by runoff to natural drainage ways. For this reason, landfills should not be constructed in highly dissected terrain, such as on hillslopes or in ravines because they are subject to intense erosion by flash floods or slopewash. Alluvial floodplains adjacent to streams and rivers should also be avoided because of erosion resulting from periodic flooding. Areas prone to overland flooding, for example certain places in the Red River Valley, are also poor places for landfill facilities.

Characterization of the site's natural materials

Knowledge of the nature and distribution of both the surface and subsurface materials at a proposed site is essential. Lithology of the formations at the surface and beneath the site are critical because lithology usually dictates the permeability of the material (permeability is a measure of the ease with which a liquid can move through a soil). Coarse-grained materials such as sand and gravel (ancient beach-ridge deposits, river alluvium etc.) should be avoided because they have high permeabilities which allow easy movement of liquids, including leachates, through and away from the site. These permeable units are also usually water-bearing and are often aquifers. Less permeable materials, such as clay, restrict movement of liquid and are considered to be one of the best materials for landfill emplacement because leachate migration is minimized and is contained in the landfill site for considerable lengths of time.

Permeability of site materials is also influenced by their structure. For example, fractures or faults in the formations enhance the permeability of the material and provide avenues for liquid movement. Although glacial till is generally considered to be relatively impermeable because of its high clay content, studies have shown that fracturing of tills can increase the permeability of till so that it is similar to that of fine sand. In western North Dakota many near-surface lignite deposits are aquifers because they are sufficiently fractured to be water-bearing.

Detailed knowledge of the stratigraphic framework beneath the proposed disposal site is needed because, although surface materials may have low permeabilities, they can be underlain by highly permeable water-bearing formations. Leachate will eventually migrate downward to these permeable layers.

The permitting process requires applicants to provide information concerning the surface and subsurface materials at the proposed site. This information is obtained through detailed description of the materials penetrated by a bore hole to a depth of 50 feet below the site. This information is supplemented, during the evaluation procedure, by data already available from the area on record at the NDGS.

Hydrogeology

The important hydrogeological factors considered in evaluating prospective landfill sites are location of major aquifers, depth to water table and velocity of groundwater movement. Understanding the groundwater flow system proximal to a proposed site is necessary for an accurate evaluation, but defining these factors requires extensive research. The research is expensive and time consuming because it requires installation of piezometers and monitoring wells and monitoring of these instruments over long periods of time. Such studies are too expensive and take too long to be used at every proposed site. For this reason, we usually have to rely on estimates of the groundwater flow system by evaluating the topography and geologic materials at the site and referring to any previously published and unpublished information concerning the hydrogeology of the site area. Responsibility of proof falls, however, on the applicant.

Prior to 1976, when the landfill concept was new, solid wastes in North Dakota were disposed of in open dumps. In 1976 the North Dakota Department of Health was assigned the responsibility of administering Solid Waste Management Regulations resulting from enactment of the North Dakota Solid Waste Management and Land Protection Act. Because of the magnitude of upgrading all open dumps to landfills, the Health Department chose to approach the problem in three phases. The first phase involved issuing a landfill permit to all applicants with only minimal consideration of the geological or hydrogeological suitability of the sites. This was done to identify all existing facilities and to educate the operators in proper landfill construction and operation techniques. That phase is essentially completed.

Phase II is an ongoing program to evaluate all the state's landfills on the basis of geological and hydrogeological suitability. As a result of these evaluations, poorly suited sites are identified and being either modified or moved to more acceptable areas. In 1977, Dr. Alan Kehew, formerly with the NDGS and now an Assistant Professor of Geology at UND, was commissioned by the Health Department to inventory the state's sanitary landfill facilities and classify them, based on available data, with respect to potential of surface and groundwater contamination. This evaluation process continues today on a priority basis of facility size and potential of environmental problems. Most of the state's major landfills have gone through this evaluation process.

The final phase of the Solid Waste Management Program is to carry out detailed research programs at major landfills in various geological provinces of the state to determine if groundwater pollution is occurring in the vicinity of the facilities. As mentioned earlier, these individual landfill studies are very time consuming and expensive because extensive drilling is required and the groundwater monitoring instruments that are installed must be observed over extended periods of time. These studies are underway through a cooperative, coordinated effort between the Health Department, NDGS, and the UND Geology Department. In addition, hydrogeology is becoming a popular topic among graduate students and many current graduate student research projects are being funded by the above-mentioned agencies and directed by research scientists employed by the agencies.

SURVEY PROFILES

Eula Mailloux

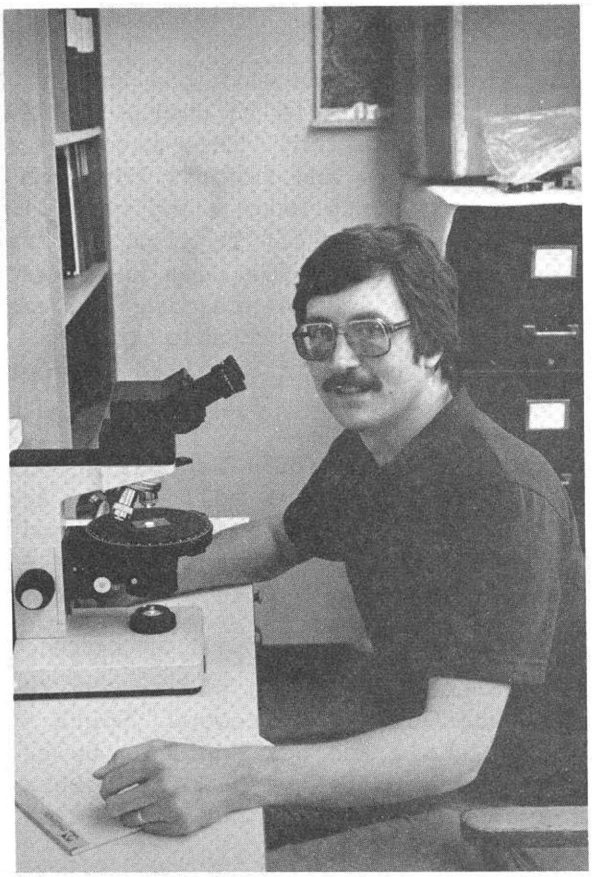
Eula Mailloux has been with the Survey since January, 1980. She is in charge of filing our oil and gas information. This involves filing numerous notices and reports for each oil well drilled in North Dakota and recording information about each well. It also involves filing exhibits and orders for case hearings that are held monthly and maintaining the tight hole file. Eula supplies available oil and gas information for requests received by phone or mail.

Eula attended Black Hills Teacher's College in Spearfish, South Dakota, as well as the Area Vocational Technical Institute in East Grand Forks, Minnesota, where she took a Nurse's Aid course and Aaker's Business College in Grand Forks, where she completed an accounting course. She had experience as a teacher in a rural school near Sturgis, South Dakota, and she taught in the primary grades in the Whitewood, South Dakota, schools. Eula and her husband, Dale, who works for the University of North Dakota Energy Research Center, enjoy square dancing in their spare time.

Julie LeFever

Julie LeFever joined the North Dakota Geological Survey as a structural geologist in September of 1980. She has been involved in helping to program the Survey's computer in addition to her work on the subsurface of the North Dakota Williston Basin. She has been employed half-time by the Survey, but she became full time on June 1, 1983. Julie is currently working on a study of the Spearfish Formation Water Sand and on the structural and sedimentologic history of the Nesson Anticline. From Los Angeles, California, Julie has B.S. and M.S. degrees in geology from California State University, Northridge.

Julie's husband, Richard, also a geologist, is an Assistant Professor of Geology in the University of North Dakota Geology Department. The LeFevers have a 6-month-old girl, Kathryn.



Dave Brekke

Dave has been with the Survey since May, 1982. He has had considerable experience in operating a variety of analytical equipment for the Survey (see the article on page 17 of this Newsletter). This involves performing tests on various materials that are sent to the Survey, analyzing and interpreting the test results, operating the scanning electron microscope/electron microprobe, x-ray diffraction, x-ray fluorescence, and polarized light microscopy on geologic and other research programs. Dave has recently been writing new rules and regulations for the NDGS for the conservation of North Dakota's non-fuel subsurface minerals and also for geothermal energy production.

Dave worked for the Minerals and Mining Resources and Research Institute of the College of Engineering at the University of North Dakota from December of 1980 until May, 1982. Prior to that, he was employed by the University of North Dakota Engineering Experiment Station, part-time by the North Dakota Geological Survey, and as a geologist for the Grand Forks Energy Technology Center of the U.S. Department of Energy. He also has field experience as a drill-site geologist.

Dave has a B.S. in Earth Science and Geography from North Dakota State University and an M.A. in Geology from the University of North Dakota. His wife, Alice, is Director of Accounting for the School of Engineering and Mines at the University of North Dakota. The Brekkes spend their free time tending a garden and spending weekends at a lake cottage near Detroit Lakes, Minnesota, in the summer and ice skating in the winter.

CHANGES IN PERSONNEL

Dave Fischer recently joined the North Dakota Geological Survey as a subsurface geologist. He has a Bachelor of Science degree in Earth Science from North Dakota State University and a Master of Science degree in geology from the University of North Dakota. David was employed as an exploration geologist by Supron Energy Corporation and Gulf Energy Corporation before accepting a position with the Survey.

Two of our geologists are on leave of absence from the Survey for 1983-84. Randy Burke is on leave to do carbonate research and to co-author a book on that research. The research is on carbonate aspects of the Mesozoic History of the High Atlas (Mountains), Morocco. Shelf carbonates in the High Atlas are similar to Paleozoic shelf carbonates in the Williston Basin, North Dakota. In North Dakota some of these carbonates are oil reservoirs and also are associated with salt and potash resources. Detailed study of outcrops in Morocco will aid in understanding North Dakota carbonates. Gerry Groenewold is on leave to devote his time to directing the North Dakota Mining and Mineral Resources Research Institute.

NEW PUBLICATIONS

The following publications were issued by the Survey during the past six months.

Miscellaneous Series 64--"Production Performance Curves of Selected North Dakota Oil Fields," was compiled by Marvin E. Rygh, Petroleum Engineer with the North Dakota Geological Survey. The publication is a folio of performance curves of selected oil fields in North Dakota. It was compiled in an effort to supply reservoir data typical of the various production regions and producing intervals within the state. Most of the fields chosen are well developed pools producing from the Mississippian Madison Formation. The remainder of the curves describe the production from the Red River (Ordovician), Stonewall (Ordovician), Interlake (Silurian), Duperow (Devonian), Tyler (or Heath of Montana; Pennsylvanian), and Spearfish (Triassic) Formations.

All of the performance curves show monthly oil production, cumulative oil production, and the number of producing wells. Most of the curves also include average reservoir pressures and gas-oil ratios. A cumulative water-injected line is included for fields subject to water-flooding.

Miscellaneous Series 64 includes performance curves for 75 oil pools. It is available from the North Dakota Geological Survey for $5.00.

Miscellaneous Map 24--"Bedrock Geology of the Lake Agassiz Region," was drawn by James T. Teller of the University of Manitoba and John P. Bluemle of the North Dakota Geological Survey. In addition to being available as a publication of the North Dakota Geological Survey, the map is also included in a journal article appearing in the Geological Association of Canada, Special Paper 26. The map, in black and white, shows the most recent compilation of the maximum extent of Glacial Lake Agassiz, as well as the major bedrock formations that are found in the area that was flooded by Lake Agassiz.

Miscellaneous Map 24 is available from the North Dakota Geological Survey without charge.

Bulletin 72, Part 1--"Geology of Morton County, North Dakota," was prepared by Clarence G. Carlson. Recent reports are also available on the groundwater basic data and on the hydrology of Morton County. The new report describes the subsurface and surface geology, the geologic history, and the economic geology of Morton County. It emphasizes the stratigraphy of the Cretaceous and Tertiary bedrock formations in the county, placing special emphasis on bedrock aquifers and on potential strippable lignite resources. A detailed, colored geologic map of Morton County, scale 1" equals 2 miles, is included, along with cross sections of Cretaceous and Tertiary bedrock formations.

The 37-page report includes 18 illustrations, mainly photos of geologic features in the county. It is available without charge from the North Dakota Geological Survey.

Bulletin 78, Part 2--"Ground-Water Data for Bottineau and Rolette Counties, North Dakota," was prepared by Ronald L. Kuzniar and P. G. Randich, U.S. Geological Survey. The report is a compilation of groundwater data for the two counties, and it includes the geologic and hydrologic data that were collected during the groundwater study. This report, Bulletin 78, Part 2, functions as a reference for the companion reports, Parts 1 and 3, which deal with geology and hydrology. Bulletin 78, Part 2 includes records of selected wells and test holes. Many of the test holes drilled by the North Dakota State Water Commission were converted to observation wells for periodic water-level measurements and water-quality sampling; the results of these measurements and sampling are included in the report.

Also included in the report are water-level readings for a large number of selected wells that tap the major aquifers in Bottineau and Rolette Counties. The largest portion of the report consists of logs collected from water-well drillers and other sources and logs of test holes drilled as part of the study. Most of the test holes drilled during the study have geophysical logs in addition to a description of the materials penetrated. These logs (gamma ray and resistivity) are extremely useful for geologic correlation purpoes.

Bulletin 78, Part 2 is 742 pages long and includes two plates that show the locations of wells in Bottineau and Rolette Counties. The report is available free of charge from the North Dakota Geological Survey.

Bulletin 79, Part 2--"Ground-Water Data for Towner County, North Dakota," was written by Ronald L. Kuzniar and P. G. Randich of the U.S. Geological Survey. Like Bulletin 78, Part 2, described above, this report is a compilation of groundwater data that provides the geologic and hydrologic information collected during the study. It functions as a reference for Parts 1 and 3 of the Towner County report, still to be published, which will deal with geology and hydrology of the county. Bulletin 79, Part 2 is 280 pages long and includes one plate which shows the location of wells and test holes in the county. The report is available free of charge from the North Dakota Geological Survey.

Report of Investigation 73--"Geology and Geotechnical Conditions of the Minot Area, North Dakota," was written by Alan E. Kehew, Assistant Professor of Geology at the University of North Dakota. This report was undertaken to compile existing information on the geology and geotechnical conditions of the Minot area, to obtain additional, more detailed information on the surface and subsurface geology of the area, and to present the information as a usable package for those involved in land-use decisions in the Minot and surrounding areas.

Along with other cities and towns in central and western North Dakota, Minot is growing. This growth, in part a response to energy development, requires accurate geological, hydrogeological, and geotechnical information for design and construction of buildings, roads, and utility lines. Geological conditions influence the type and cost of structures that can be built and determine the safety or risks of damage to the structure by active geological processes such as flooding or landsliding. Growth also necessitates the location and development of water supplies, deposits of materials used in construction, and sites which can be used for waste disposal. The geological setting of an area is the key to meeting the requirements of expansion and development.

The report includes maps and cross sections detailing the geology and engineering properties of near-surface materials in the Minot area, groundwater aquifers in Quaternary deposits, generalized geotechnical conditions, geologic and hydrogeologic conditions pertaining to waste disposal, and other information as well. The 35-page report includes six plates and is available from the North Dakota Geological Survey for $2.00.

Report of Investigation 76--"Depositional Environments and Sandstone Diagenesis in the Tyler Formation (Pennsylvanian), Southwestern North Dakota," was written by Stephen D. Sturm. This new publication provides an interpretation of the depositional environments of the Tyler Formation sediments in southwestern North Dakota. The Tyler Formation produces oil in the Dickinson area. An understanding of the depositional history and facies relationships in that area may be an aid in interpreting depositional environments and the oil reservoir potential of the formation in other areas. The study is based on cores stored in the Wilson M. Laird Core and Sample Library and on well-log files maintained by the North Dakota Geological Survey. Six plates are included in the 48-page report, which sells for $2.00.

Report of Investigation 77--"Earth Resistivity Investigations in Reclaimed Surface Lignite Mine Spoils," was written by A. E. Kehew, UND Geology Department, and G. H. Groenewold, North Dakota Geological Survey. The purpose of the study was to investigate and compare reclaimed spoil areas with adjacent undisturbed settings using earth resistivity techniques, which have been found useful in several types of subsurface studies. Using one of the techniques, the resistivity and thicknesses of subsurface layers can be determined where layers contrast in resistivity. Another major application involves determining changes in groundwater quality usually associated with contamination of some type. If spoils resistivity varies in a systematic and detectable way, the resistivity patterns could be related to the physical and chemical variables affecting reclamation. Periodic resistivity surveys could then be used to determine initial postmining subsurface spoils conditions and, later, to monitor hydrogeologic changes in the spoils. Surveys were made at three lignite mines, Center, Indian Head, and Falkirk, and in reclaimed spoils at two mines, Center and Indian Head. The results of the study show that resistivity could be used as a tool for evaluating groundwater degradation following mining and reclamation. The higher the resistivity of the overburden materials, the better the quality of groundwater below reclaimed spoils that can be expected. Report of Investigation 77 is 92 pages long and is priced at $2.00.

Geologic Postcard. The Survey recently issued a new postcard that depicts the geology of North Dakota in color. The card measures 5" x 7" and has a glossy face. It is available free of charge from the North Dakota Geological Survey.

HOW GEOLOGY AFFECTED WHERE PEOPLE SETTLED IN NORTH DAKOTA

--John Bluemle

Even though early North Dakotans probably did not often consciously decide where to live based on knowledge of the local geology, differences in the terrain, availability of resources, and other factors sometimes influenced their choice of homesites. That was the presumption I began with last February when I taught a Communiversity course at the University of North Dakota entitled "Settling North Dakota: The Relationship Between Geology and Where People Chose to Live." Communiversity is an effort to bring community and university people together for courses or dialogs in continuing education. Similar programs are conducted at other colleges and universities. Communiversity at UND is held on the four Sundays in February and it consists of non-credit courses in topics such as theology, church life, humanities, sciences, and personal and family concerns. During the four-session course (two hours each session), I attempted to examine some of the factors that influenced where people chose to live in North Dakota, beginning with the Native Americans, and continuing with a look at where Europeans of various nationalities settled. The emphasis was on rural North Dakota, but the immigrants of various nationalities who settled in the smaller, urban areas established townsites with distinctive, differing characteristics.

I'm not sure I convinced anyone in the class that any real connection exists between geology and where people settled, but if instead of "geology" we read "natural environment," then I think it is possible to show definite correlations. Clearly, the Native Americans were concerned about the availability of water, building materials, food, fuel, and in some cases, the suitability of the land for agriculture. All of these factors ultimately depend on the geology or natural environment.

The earliest European explorers to North Dakota, LaVerendrye and his sons in 1738-1743, apparently guided themselves by referring to certain landmarks such as the Turtle Mountains and Dogden Butte. Later, Lewis and Clark, in their exploration of the Missouri River country, made numerous references to lignite, and they themselves used lignite in various ways.

In the 1860s, steamboat pilots attempted to use lignite as a fuel. Also in the 1860s and 1870s, Forts Rice, Buford, Stevenson, and Lincoln were constructed along the Missouri River. Personnel from these forts used lignite when they could, with mixed success.

Later, during the Settlement Period of the 1870s and 1880s, the railroads, especially the Northern Pacific, in an attempt to get people to settle in Dakota, published many articles, pamphlets, etc. describing the exceptional aspects of Dakota such as the rich soil, moderate climate, and extensive coal resources. A promotional blurb from an 1882 NP brochure reads:

> "As there are no large bodies of timber in Dakota, and no beds of the anthracite and bituminous coal found in the East, it is supposed by many that this country is entirely destitute of fuel, and that its only means of supply is by purchasing in the East at the most exorbitant rates. This is an error. Beds of LIGNITE coal are found in this locality in almost inexhaustible quantities. This coal is entirely free from sulfur, stone, and other foreign elements. It burns up as clean as wood, without waste, and without clinkers or cinders."

The Territorial Government also provided promotional materials. This is from 1887:

> "This lignite, or brown coal, is of soft variety, excellent for heating purposes, and ... superior to almost any coal discovered on the continent... lignite burns readily and furnishes the settlers of a prairie country with that inestimable boon, cheap domestic fuel."

Newspapers also had a lot to say. The March 24, 1884 edition of the Bismarck Tribune, regarding McLean County, the "heaven-favored territory:"

> "The inexhaustible beds of lignite coal, which underlies so much of this locality, are of untold value to the settler. It makes excellent fuel, and can be supplied at a reasonably low cost. This coal is being largely used in lieu of wood, and for both heating and cooking purposes it meets every requirement...These immense deposits of lignite stretch far away on every side, and their value to the country can never be estimated."

The literature published and circulated by government officials, the railroads, and the newspapers, lured thousands of eastern Americans and Europeans to North Dakota, and the resulting influx was known as the "Great Dakota Boom." People emigrated from the British Isles, Germany, Russia, Norway, and from a host of other European countries. Many immigrants came individually, while others joined large colonization groups. Several villages and towns in western North Dakota, such as New Salem, Glen Ullin, Richardton, Gladstone, and Dickinson, were the result of these colonization projects.

Another "natural environment" factor that influenced the distribution of the early settlers in North Dakota, particularly in the Red River Valley, was the periodic severe flooding along the rivers. The earliest permanent settlement in what is now North Dakota was Pembina, which was established before 1800. Although it was mainly a Métis settlement, other colonists such as Swiss and Scotch people settled there about 1812. However, as a result of the deep snows of 1825-26, the Red River flooded so badly that these Swiss people left, and emigrated to Illinois. The town of Pembina in the mid 1800s was not like people would have expected a village to be. In 1849, when it had a population of about a thousand, most of the people--both whites and Métis--lived in skin or bark lodges. This was because of the many spring floods, which washed everything away every year. Finally, in about 1853, most of the inhabitants of Pembina moved to St. Joseph (now Walhalla) because of the floods of the early 1850s, probably especially the 1852 flood.

Much of the Red River Valley was settled earlier than most of the rest of North Dakota, mainly because of Lord Selkirk's Red River Settlement (or "Assiniboia") in the modern Lower Fort Garry-Winnipeg area. At the time of the Red River cart trails, before the railroad was completed east-west across Canada, the Red River Settlement (Winnipeg) was dependent on north-south trade to St. Paul. Commerce between Winnipeg and St. Paul followed two main routes in North Dakota and several in Minnesota. The first of the North Dakota routes, the "Ridge Trail," followed the beaches along the edge of the lake plain because the land there was generally drier, sandier, and had less mosquitoes. It also offered a better view, lack of woods, and thus less likelihood of ambush by the Sioux. The second North Dakota route was the "West-Bank River Trail," which was used mainly in dry years in autumn and winter. It followed the river, encountering many marshes, sinkholes, and muddy areas. Near the Red River, tributaries such as the Park and Forest Rivers are quite large and crossing them presented some problem. They were also so salty that they couldn't be used for drinking or cooking. It wasn't until 1871 that the stage route between St. Paul and Winnipeg was in operation and, with it, bridges and daily mail service.

For those of you interested in the distribution of the various ethnic groups found in North Dakota, I recommend a new (1983) book entitled "Prairie Mosaic: An Ethnic Atlas of Rural North Dakota," by William C. Sherman. Sherman's book provides a comprehensive analysis of the surprisingly large number of ethnic groups who came to early North Dakota. It includes maps showing where these groups were located as of 1965, and it presents something of both the times of settlement and the various social institutions around which the national communities were known to have rallied.

Although it was not Sherman's intent to tie the settlement patterns to the geology or natural environment, on reading his book I was able to extract numerous examples of how the early settlers were influenced, in various ways, by the environment. I've included just a few examples I took from his book.

One example is the Anglo-Americans, people of British background. Wherever they settled in North Dakota, the Anglo Americans tended to choose the rougher areas, becoming ranchers; and many are still ranchers. The rugged badlands area of south-western North Dakota, for example, is populated almost entirely by Anglo Americans. Many Anglo Americans entered southwestern North Dakota from Montana and South Dakota. These people belong to the western cattle culture (the "cowboys") and, indeed natural affinity seems to exist between cattle raising and a British background. Many of these people came with the trail herds that moved up the eastern slopes of the Rocky Mountains. They generally preceded the "dirt-farmers," but they still chose to settle in the rougher areas.

The Germans from Russia came as a result of railroad advertising and favorable reports of advance scouts. They were cautious and methodical; they sent advance scouts to an area they were considering and, if the reports were favorable, they then moved in in force with people and goods. The German-Russians were farmers, not cattle people. They had a tradition of farms, vineyards, and gardens on the steppe. For this reason, they avoided rough country (one of their quotations reads: "Every hill was a thorn"). Life on the steppe had made them suspicious of mountains and comfortable on the plains of North Dakota, although prior to moving to Russia they had come from the hills and forests of Germany. They knew how to build an adobe home, how to lay out farmsteads, build a root cellar, dig a well, all of this from their previous Russian experience. Usually the German-Russian practice of choosing lands similar to those with which they were familiar was successful, but in a few cases this attitude led to serious mistakes. In Pierce and McHenry Counties, for example, the German-Russians chose the sand hills (collapsed outwash and lake-plain dunes) because the sand areas in Russia from which they had come were good farmland in that climate. In North Dakota, however, where the climate is drier, sand hills often were a disaster. After the topsoil was disturbed, the land began to blow away. The German-Russians are the only major ethnic group in North Dakota that expanded northward (out of South Dakota) across the more customary east-west settlement pattern. German-Russian people living in north-central North Dakota are also quoted as saying that "there were too many rocks down in southern North Dakota" and that's why they moved north, but this generalization doesn't make sense geologically, because both areas are essentially similar in that respect.

Icelanders who had settled near Gimli, Manitoba, in about 1875 moved south in 1878 to the edge of the Red River Valley to the Mountain, Hallson, and Gardar areas. These people chose a sandy, somewhat rocky area along the former shoreline of glacial Lake Agassiz. In view of the fact that better land was available on the lake plain, it is difficult to see why they chose this land. Possibly the hillier land reminded them of "home." Later, in the 1890s, Icelandic people settled in north-central North Dakota in the Souris River hills, woods, and adjacent marshlands, also an unfortunate choice from an agricultural point of view.

The first Norwegian settlers to North Dakota arrived before 1870 in the Wild Rice River area of Cass County and the Fort Abercrombie area of Richland County. They were farmers and their farms commonly extended from the rivers onto nearby prairies. The Norwegians usually chose areas near the river valleys and the old observation that Norwegians "liked the valley" seems to hold true in North Dakota, especially the Sheyenne and Goose River Valleys. The presence of the rivers and creeks definitely affected how the Norwegians arrived and their dispersal pattern through the state. They followed the Sheyenne and Goose Rivers upstream and, in fact, the Sheyenne is an almost exclusively Norwegian river from southern Cass County for almost 200 miles upstream. Similarly, in north-central North Dakota, the Norwegians settled first along the Souris River in Bottineau County, then they filled up the treeless prairie. They also settled along the south edge of the Turtle Mountains where water and wood were abundant. The earliest Norwegians in Bottineau County were country people who did not like towns and villages. For example, in 1886, of the 100 people living in Dunseith, only one was a Norwegian (he ran the saloon).

People of Belgian ancestry came to parts of northwestern North Dakota from Minnesota in the early 1900s. These people originally came to work in the coal mines in that area, but they eventually became farmers. Finnish settlers seemed to prefer timber and hillside areas and, because of this preference, they generally ended up with relatively poor quality land. The French settlers, who arrived before 1870, usually chose land that included a combination of water, woodland, and prairie; they avoided the open prairie. A typical French "farm" was a "long lot," which extended from the water line, through the trees, and out onto the prairie. The French settlers were not aggressive in their acquisition of land and although they arrived early and presumably had their choice of the best and as much land as they might have wanted, they kept their holdings small.

The first Ukrainians homesteaded in the Belfield area in 1896. They had lived on the Russian steppe, and most of them came initially to farm, choosing (for example) the better homestead lands in the area between Belfield and the badlands. Some of them came to work in the coal mines in the early 1900s. The Ukrainians built the well-known adobe-type houses and barns found in southwestern North Dakota. The Grassy Butte "sod post office" is, in fact, a typical Ukrainian log-clay structure, not a sod structure.

FLUCTUATING LEVELS OF DEVILS LAKE

--John Bluemle

Recently, the rising water levels of Devils Lake (fig. 1) have been in the news and, in fact, Governor Olson issued a Disaster Emergency Proclamation on May 18, 1983, regarding these high water levels. In view of the damage being done to roads and property as a result of the rising lake, it may be interesting to consider how the level of Devils Lake has fluctuated in the geologic past. Much of the information in this article is adapted from two Ph. D. dissertations written on Devils Lake by University of North Dakota geology students. The first of these, "The postglacial sedimentology of Devils Lake, North Dakota," was written in 1968 by Edward Callender. Callender studied cores of sediment taken from the bottom of Devils Lake. His studies concentrated on diatom frustule content of the cores, interstitial sulfate content, calcium/iron ratios, and magnesium-calcite/calcite ratios. The second thesis, "Postglacial ostracod distribution and paleoecology, Devils Lake Basin, northeastern North Dakota," was written in 1980 by James B. Van Alstine. Van Alstine also studied lake-bottom cores, comparing the paleoecology of the ostracod fauna as it changed through time, and relating the changes in ostracod fauna to environment in the lake at various times. Ostracods are small crustaceans, aquatic animals with shells; other crustaceans include the lobsters, crabs, crayfish, and shrimps, although ostracods are much smaller than most of these animals.

Throughout Holocene time, water levels and the salinity of Devils Lake have fluctuated widely. Callender documented five major and several minor fluctuations in the level of the lake beginning about 6500 years ago (that's as far back as his study went; changes occurred before then, too). At least seven periods of low water

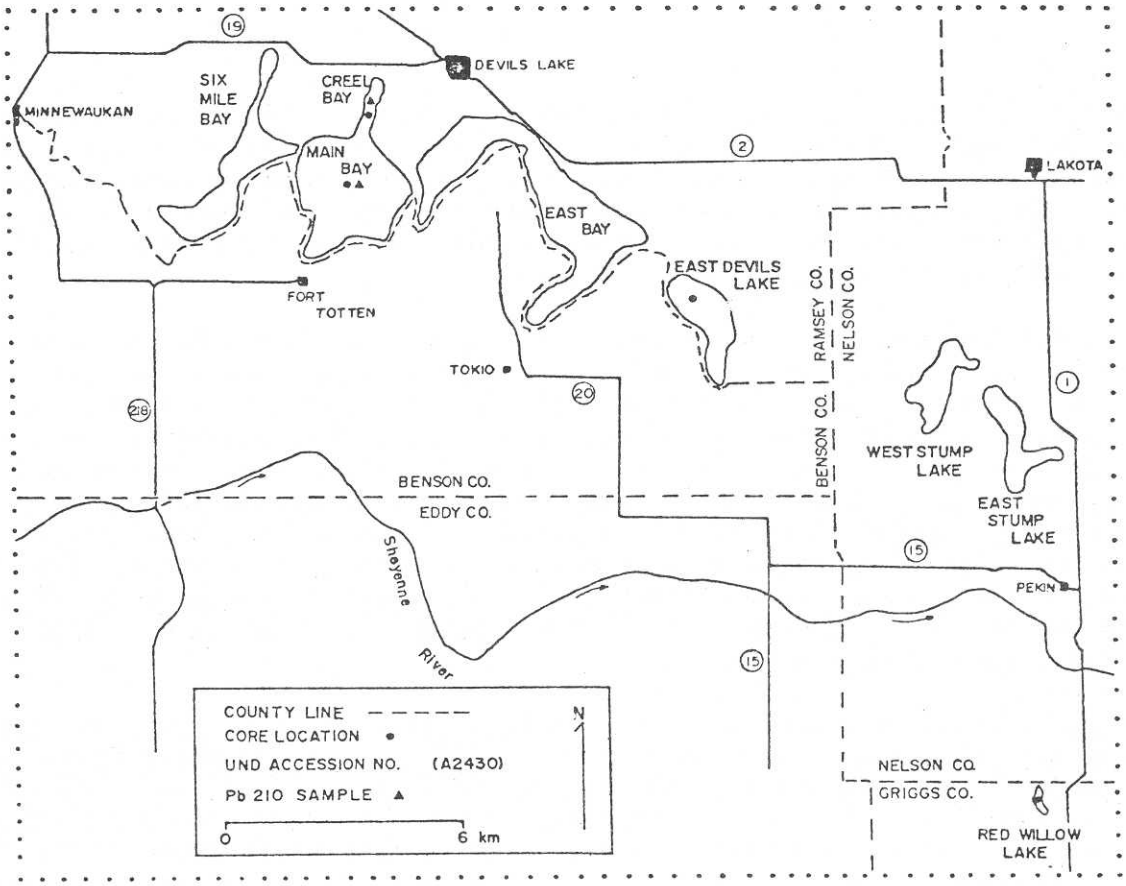


Figure 1. Map of the Devils Lake area.

level and brackish (salty) conditions were recognized by Callender, and the lake is thought by some to have dried up completely for a time during the Hypsithermal Interval, a period of warm, dry climate that reached its greatest intensity sometime between 8500 and 5500 years ago. Generally, the Devils Lake environment has always been unstable (see fig. 2 for a chart showing how the lake has fluctuated through time). Relatively high lake levels (probably higher than 1430 feet; the level of the lake right now is about 1428 feet) occurred about 4300, 3500, 2300, 1250, 1000, 750, and 250 years ago. These dates tend to coincide with periods of cooler, wetter climate in the Northern Hemisphere. Relatively low lake levels occurred about 6000, 4000, 3000, and 500 years ago, times coinciding with periods of warmer, drier climate in the Northern Hemisphere.

The manner in which the level of the lake can rise and fall is illustrated by Callender's analysis of the period of time between 1200 years ago and 700 years ago. The lake level declined at least 10 feet between 1200 and 1000 years ago. It then rose at least 14 feet in approximately 100 years (to 900 years ago) after which it declined at least 14 feet (to 800 years ago). Another rise in lake level of more than 14 feet occurred about 700 years ago, but this rise was also short-lived and the level began to decline again within a matter of 50 years. Historical records of fluctuations in the level of Devils Lake show that, in 1830, the lake was at an elevation of 1441 feet, about 13 feet higher than it is today. It gradually declined between 1860 and 1940 when it was only 3 feet deep and at a level of 1400 feet.

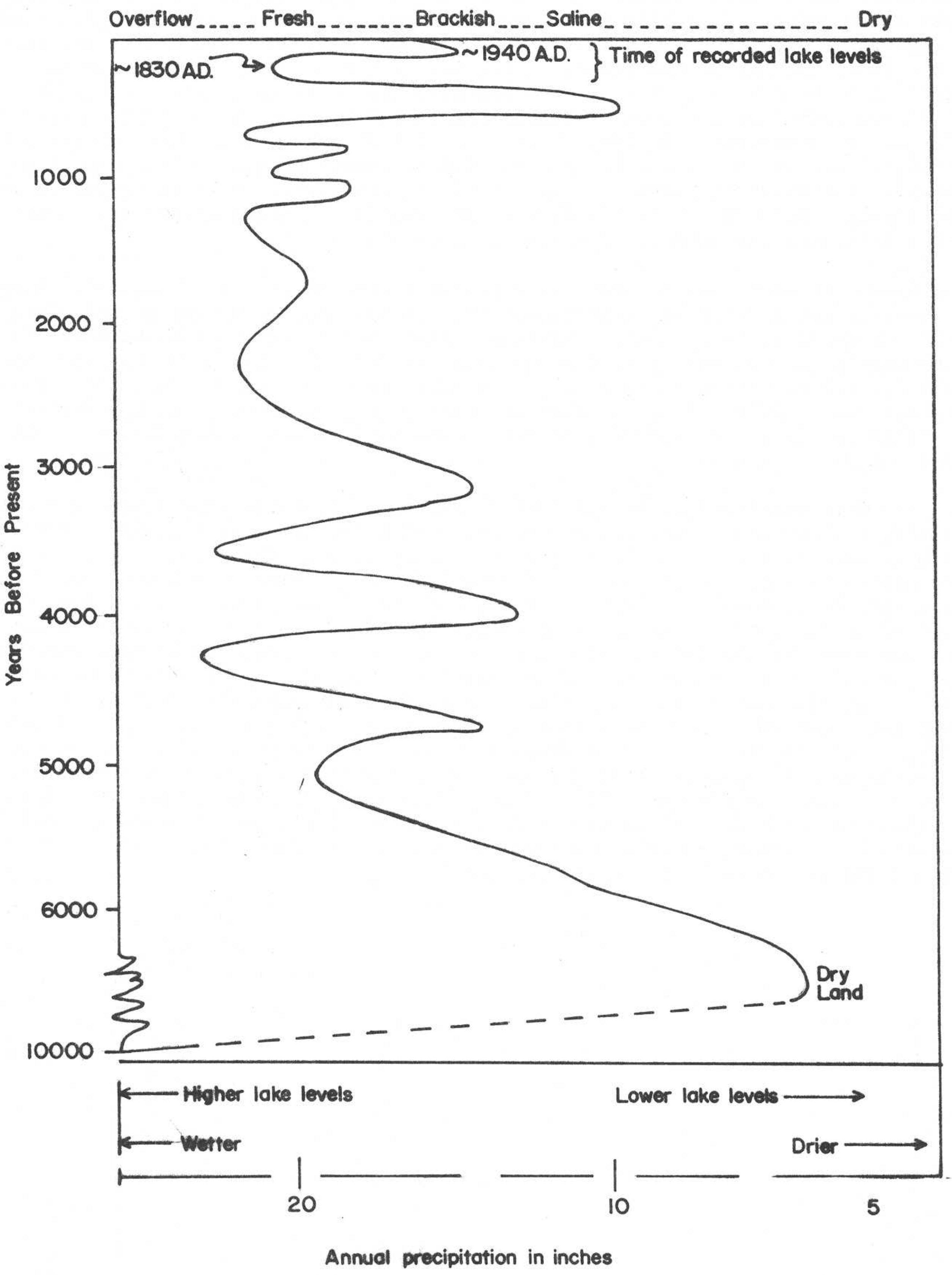


Figure 2. Chronology of fluctuating lake levels of Devils Lake. Adapted from Callender, 1968.

It has been calculated that groundwater flows can account for 20 to 30 percent of the water entering Devils Lake. However, I am not certain when this figure was calculated and it seems likely that the amount of water entering or leaving the lake might range between much higher and lower extremes, depending upon climatic conditions. The Spiritwood Aquifer, which lies beneath Devils Lake, extends well beyond the limits of the lake, and beyond the limits of the Devils Lake drainage basin. In fact, it extends all the way from the Canadian boundary to the South Dakota border, and it is interconnected by a system of buried preglacial valleys to aquifers several hundred miles to the southwest. In 1980 it was calculated that in Ramsey County alone the Spiritwood Aquifer had approximately 990,000 acre-feet of groundwater available from storage. The amount of water in the aquifer is far greater than is contained in Devils Lake itself (the amount of water in the lake changes greatly, of course, as the level of the lake, and its extent, increases or decreases).

Cycles of increased and decreased precipitation affect the groundwater supply, but because the movement of groundwater through the aquifer system is relatively slow, rises and declines in the lake level that might result from such changes in the groundwater supply are not easily tied to obvious climatic cycles. Such rises and declines would lag behind climatic cycles by an unknown number of years. Currently, Devils Lake apparently is receiving an abundant supply of groundwater from the aquifer that underlies the lake. Conversely, at times when aquifer levels are low, the lake probably loses water to the aquifer.

Why does the level of Devils Lake fluctuate so dramatically? Are man's actions--draining wetlands, agricultural practices, road building, dike building, changing drainage routes, etc.--the reason for the recent rise in the level of Devils Lake? The purpose of this article is not to give definitive answers to these questions, but simply to provide an "account" of some of the changes that have occurred in the level of Devils Lake during the past several thousand years and speculate on what they may mean for the future. While no definite predictions can be made about what the lake will do in the future and no definite statement can be made as to why the level of Devils Lake rises and falls, it should be apparent that changes in the lake level have been the rule rather than the exception. The lake level rose to 1440 feet several times in the past and it dropped to levels lower than 1400 feet several times. It should also be apparent that all past changes in the lake level occurred in response to natural climatic changes. Even though draining of wetlands or current agricultural practices probably do have an effect on the modern landscape, it seems unlikely that the effects of these and other cultural practices are significant with respect to overall changes in the level of Devils Lake.