THE SILURIAN SALT DEPOSITS IN EASTERN LAKE, NORTHWESTERN ASHTABULA, AND NORTHEASTERN GEAUGA COUNTIES, OHIO

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Water Resources Division

THE SILURIAN SALT DEPOSITS IN EASTERN LAKE, NORTHWESTERN ASHTABULA, AND NORTHEASTERN GEAUGA COUNTIES, OHIO

by Stanley E. Norris

An addendum report to accompany Open-File Report 78-684, "Hydrologic environment of the Silurian salt deposits in parts of Michigan, Ohio, and New York."

Prepared for the U.S. Department of Energy

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Columbus, Ohio

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Conversion Factors

Factors for converting English units to the International System of Units (SI) are given below:

Multiply English units	by	to obtain Si units
inches (in)	25.40	millimeters (mm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

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ABSTRACT

Five salt zones, comprising single or multiple salt beds interbedded with dolomite, dolomitic shale and anhydrite, occur in a 250-square-mile area in eastern Lake, northwestern Ashtabula, and northeastern Geauga Counties, Ohio. The aggregate thickness of salt-bearing rocks, from the base of the lowest salt to the top of the highest salt, ranges from about 300 feet in the northern part of the area to more than 450 feet in the southern part. The aggregate thickness of salt, exclusive of the intervening rocks, also increases southward, from about 100 feet to more than 200 feet. The thickest salt bed, the F1A salt, is 35 to 38 feet thick in northeastern Geauga and southeastern Lake Counties.

INTRODUCTION

This addendum report was prepared for the U.S. Department of Energy (DOE) under provision of interagency agreement No. EY-76-C-05-4399, between DOE and the U.S. Geological Survey. It is a supplement to the open-file report, "Hydrologic environment of the Silurian salt deposits in parts of Michigan, Ohio, and New York," by S. E. Norris (see References). That report describes in general terms the occurrence and fluid environment of the salt beds and recommends for additional investigation two areas in Michigan, one area in Ohio, and one area in New York. In these areas the salt beds are less than 3,000 feet below the surface and appear of sufficient thickness to warrant consideration as possible repositories for nuclear waste.

This report presents information about the occurrence, thickness, and character of the salt beds in the recommended study area in Ohio, and is intended primarily as a guide for the selection of sites for test drilling.

The area of interest contains about 250 square miles and is outlined on most of the illustrations in this report. It extends from Painesville on the west to Ashtabula on the east, and from the lakeshore south to the vicinity of Chardon (fig. 1).

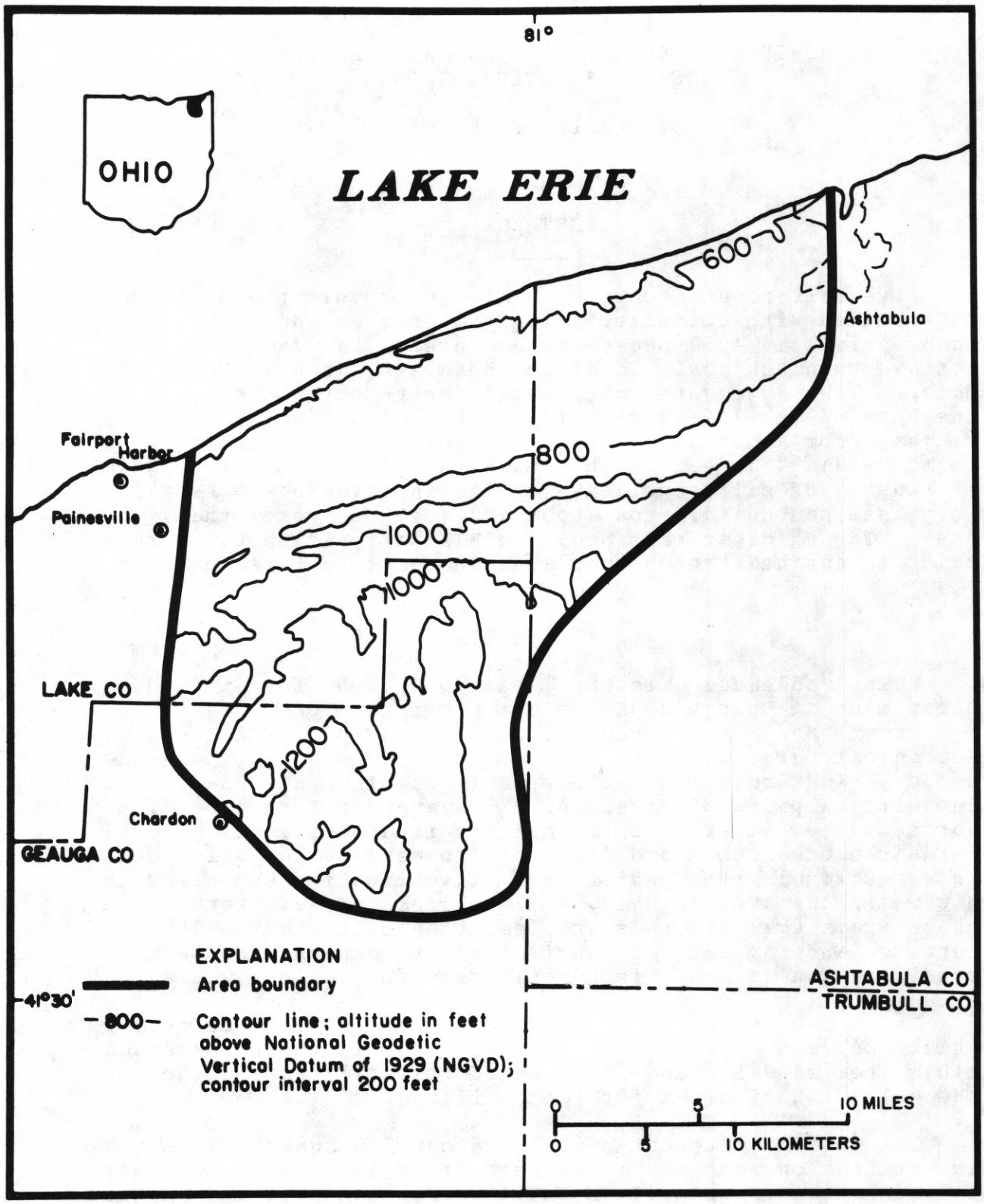


Figure 1.--Topography of the land surface.

The land surface is relatively flat in a 5-mile-wide band along the lakeshore but becomes hillier and higher to the south (fig. 1). It reaches an altitude of more than 1,200 feet in the southern part of the area.

Data on the salt beds were derived chiefly from geophysical logs of oil and gas wells in the files of the Ohio Division of Geological Survey. The location of the wells and their state permit numbers (used for identification) are shown in figure 2. Table 1 lists the salt beds and their depths and thicknesses as determined from the logs. The log data are supplemented by data from a few core or sample descriptions, also from Ohio Division of Geological Survey files.

Gamma, compensated density, and caliper logs were used to identify the salt beds. Clifford (1973, p. 3-5) describes the basis for the interpretation. The clarity with which the salt beds are revealed by the logs is shown by the example in figure 3.

OCCURRENCE OF THE SALT BEDS

The salt beds in northeast Ohio are part of the Salina Formation of Silurian age. This formation consists chiefly of carbonate rocks (limestone and dolomite) that are bounded above and below by thick shale beds and that occur near the middle of the stratigraphic sequence. The carbonate-rock section is known to oil-and-gas-well drillers as the "Big lime." The position of the "Big lime" within the general sequence, and that of the salt beds within the "Big lime," are shown in the generalized columnar section which appears, as an inset, in figures 4 through 8.

Five generally recognized zones of salt-bearing rocks occur in the area of interest. These zones contain either single or multiple beds of salt, interbedded with dolomite, dolomitic shale, and anhydrite. The salt beds are designated, in ascending order, as the B, D, E, F1 and F2 salts. The D salt consists typically of two beds and the F1 salt of three beds, identified by letters as shown in table 2. No letter designations are given the multiple beds of the B salt. All these salts are present in the southern half of the area of investigation; the E, F2, and F1 salts, however, disappear from the stratigraphic sequence progressively northward, as shown in figure 4.

The depth to the uppermost salt bed ranges from about 1,900 feet along the lakeshore to about 2,900 feet near the southern boundary of the area of interest. The increase in depth results from both the relatively high terrain in the

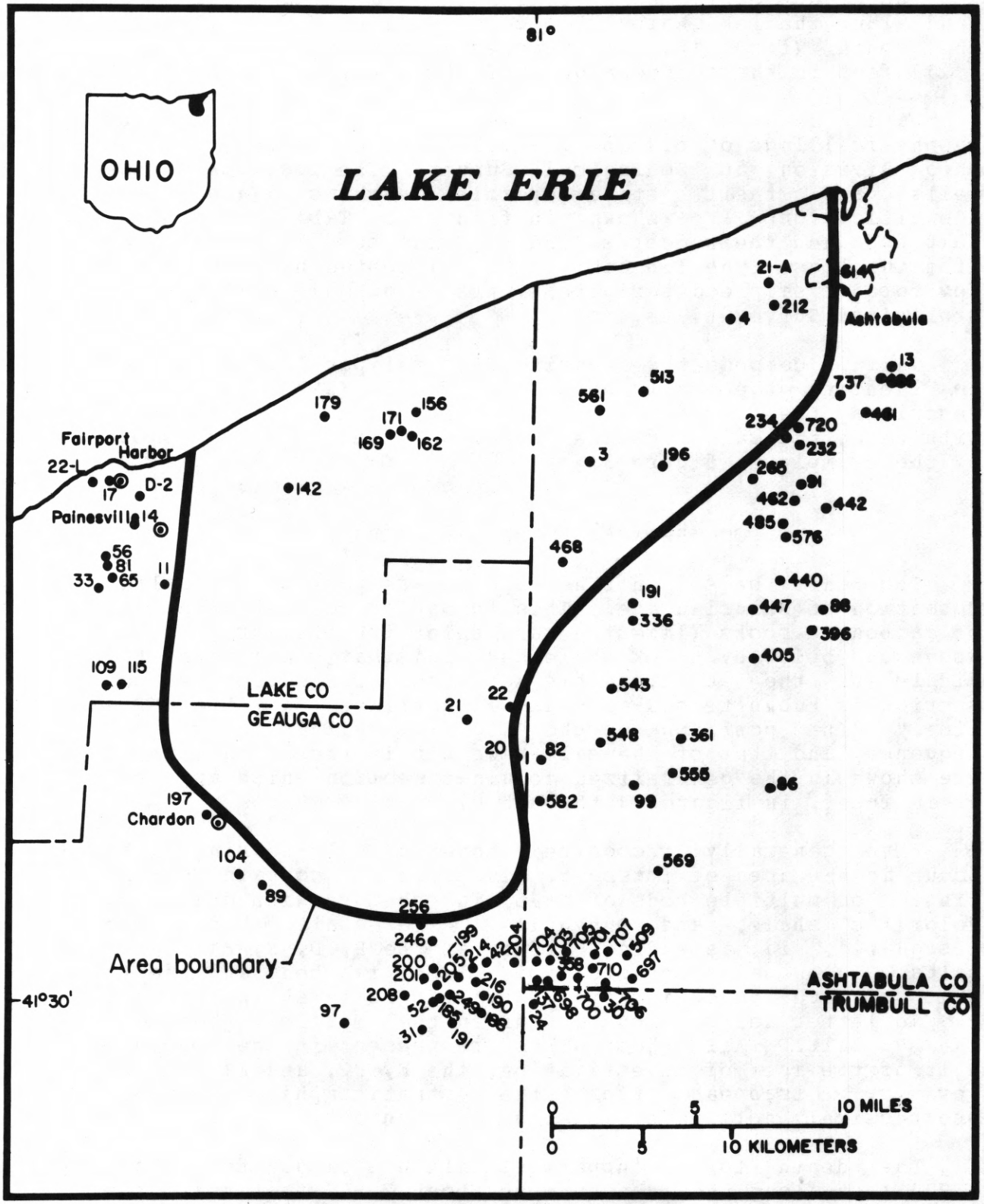


Figure 2.--Location of wells listed in table 1 (number is state permit number).

Table 1.--Data on salt beds (from logs and core descriptions of oil and gas wells; locations shown in figure 2).

State permit no.	Altitude (ft)	Depth to "Big lime" (ft)	Depth to F2 (ft)	Thickness of F2 (ft)	Depth to F1 (ft)	Thickness F1A (ft)	Thickness F1B (ft)	Thickness F1C (ft)	Depth to E (ft)	Thickness of E (ft)	Depth to D (ft)	Thickness DA (ft)	Thickness DB (ft)	Depth to B (ft)	Aggregate thickness B (ft)	Interval top to base B (ft)	Aggregate thickness all salts (ft)
614	724	--	--	0	--	0	0	0	--	0	2173	4	16	2309	69	89	89
91	852	1723	--	0	2296	28	14	--	2382	2(?)	2449	--	35	2580	82	124	161
232	876	2730	--	0	2220	30	10	20	2360	4(?)	2390	6	18	2520	52	80	140
234	834	1702	--	0	2274	44	--	--	--	0	2368	6	18	2512	58	66	126
265	823	1657	--	0	2236	28	26	--	2344	4	2400	6	28	2520	64	96	156
442	845	1722	--	0	2282	30	28	--	2398	4	2450	8	26	2606	60	90	156
462	856	1732	--	0	2302	32	22	--	2410	3	2462	8	30	2588	62	94	157
485	838	1727	--	0	2296	66	--	--	2418	4	2468	16	24	2615	74	101	184
576	835	2820	--	0	2302	31	34	--	2424	4	2476	6	34	2601	77	123	186
720	838	1682	--	0	2250	36	--	--	2330	4	2384	6	28	2524	54	68	128
513	710	1479	--	0	2050	38	--	--	--	0	2182	8	33	2310	80	130	159
56[1]	689	1445	--	0	2033	44(?)	--	--	--	0	2163	8	33	2294	99	133	184(?)
3[1]	820	1598	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
196	861	1722	--	0	2308	38	--	--	--	0	2426	8	24	2548	82	122	152
468	1004	1859	--	0	2448	34	30	--	2568	3	2622	10	26	2752	97	134	200
82	1085	2013	2604	28	2662	34	30	--	2782	4	2838	4	26	2972	70	96	196
99	976	1950	2540	27	2595	35	30	--	2718	4(?)	2773	12	27	2913	61	119	196
361	807	1779	2325	23	2378	38	30	--	2504	4	2560	6	28	2696	66	124	195
543	1016	1961	--	0	2530	40	32	6	2673	3	2726	8	30	2864	67	126	186
548	1031	1969	2555	17	2600	38	40	--	2734	6	2787	10	22	2918	68	102	201
555	810	1806	2364	30	2420	42	36	--	2546	6	2602	10	30	2714	71	126	225
582	1088	2045	2636	28	2694	32	26	--	2810	4	2870	8	24	2998	80	128	202
88	882	1802	--	0	2350	30	8	--	2448	4	2500	5	25	2642	64	128	136
396	862	1801	2302	8	2326	42	26	6	2456	3	2506	9	28	2642	84	130	206
405	818	1761	2276	7	2309	32	28	--	2425	4	2480	4	25	2610	84	140	184
440	829	1752	--	0	2284	42	36	--	2414	6	2464	10	33	2592	82	134	209
447	818	1731	--	0	2272	32	36	--	2410	3(?)	2450	5	30	2579	112(?)	145	218
13[1]	838	1715	2237	36	2310	42	25	3	--	0	2471	--	14	2516	85	85	205(?)
461	861	1706	--	0	2266	44	--	--	2350	5(?)	2392	4	22	2520	72	100	147
686	849	1650	--	0	1369	6	24	--	2288	4	2342	6	24	2460	62	96	126
737	838	1610	--	0	2170	58	--	--	2264	6	2318	6	28	2440	64	128	162
86	875	1858	2428	22	2480	33	30	--	2600	8	2656	6	32	2807	97	125	228
4[1]	651	1368	--	0	--	0	0	0	--	0	2052	9	26	2221	43	67	78(?)
21-A	636	1378	--	0	--	0	0	0	--	0	2034	6	16	2146	60	101	82
212[1]	682	1356	--	0	0	0	0	0	--	0	2036	6	28	2184	70	100	104
191	984	1895	2453	20	2502	32	28	4	2620	5	2674	3	24	2802	80	106	196
336	982	1904	2470	18	2504	35	20	4	2626	3	2676	5	30	2808	75	136	190
137	1073	2228	2820	18	2855	42	37	15	3016	10	3084	10	32	3226	52	103	216
358	1041	2174	2762	23	2802	36	24	12	2942	8	3003	10	23	3140	47	80	183
509	865	1939	2536	32	2586	36	30	12	2732	8	2794	8	28	2940	66	98	220
569	810	1076	2456	8	2458	40	36	--	2624	6	2682	18	30	2822	76	122	212
697	809	1964	2554	38[2]	2614	36	36	10	2764	8	2828	10	28	2964	50	108	216
698	1036	1132	2760	22	2800	40	28	12	2946	10	3010	10	30	3156	46	86	198
700	988	2130	2718	26	2764	44	40	10	2918	8	2978	10	30	3122	48	88	216
701	987	2118	2717	15	2754	42	46	8	2907	7	2969	10	31	3113	61	97	220
703	1069	2189	2780	20	2816	42	26	16	2972	12	3036	8	28	3180	44	84	196
704	1094	2212	2806	24	2848	34	32	8	2994	8	3056	10	28	3168	42	100	186
705	1043	2166	2762	20	2800	38	30	8	2948	8	3014	6	24	3152	54	90	188
706	924	2076	2668	40[2]	2732	46	36	8	2878	6	2934	8	26	3074	54	100	224
707	949	2071	2674	26	2718	36	34	10	2866	4	2926	8	28	3070	48	90	194
710	991	2119	2706	36[2]	2764	44	32	8	2916	10	2976	10	30	3122	54	90	220
97	1265	2310	2964	32	3014	42	28	6	3160	8	3227	10	26	3398	31	48	183
197	1227	--	2754	38	2818	34	32	4	2946	8	3009	12	28	3146	76	108	232
89	1255	2155	2792	32	2852	35	32	8	2982	8	3050	12	20	3180	64	115	211
42	1118	2196	--	0	2830	42	44	10	2986	10	3048	11	32	3200	68	110	217
199	1109	2189	--	0	2816	36	40	8	2968	6	3032	12	24	3174	56	110	182
200	1147	2193	2810	12	2852	34	24	--	2984	10	3046	10	20	3190	44	96	154
201	1186	2238	2854	30	2912	34	20	--	3038	6	3100	10	24	3240	50	88	174
204	1124	2232	2832	24	2872	38	36	8	3020	10	3084	10	30	3228	58	92	214
205	1154	2201	2818	30	2862	34	22	30	2998	8	3060	10	26	3206	52	86	212
214	1119	2180	2788	20	2824	42	28	10	2970	10	3036	10	26	3180	46	88	192
216	1122	2202	2810	16	2842	34	36	10	2988	8	3050	10	24	3194	44	88	182
246	1214	2243	2870	20	2904	36	30	10	3042	10	3108	10	28	3250	54	92	198
256	1283	2302	2932	14	2962	22	24	6	3098	8	3164	6	10	3306	56	112	146
31	1137	2191	2846	12	2876	40	36	8	3024	13	3090	10	30	3262	38	72	187
52	1154	2204	2822	16	2854	38	40	6	3000	8	3060	14	30	3204	54	84	206
185	1121	2197	2806	34	2856	38	22	10	2994	12	3058	8	28	3198	50	88	202
188	1154	2252	2856	22	2902	46	40	10	3064	8	3128	10	26	3266	44	72	206
190	1123	2205	2814	34	2862	36	20	10	3002	6	3068	10	26	3212	58	84	200
191	1136	2193	2826	26	2862	36	38	10	3012	8	3080	10	24	3224	44	84	196
208	1231	2275	2896	24	2934	44	30	8	3078	10	3142	10	26	3272	48	92	200
249	1133	2193	2808	18	2842	36	32	8	2988	8	3052	8	26	3196	74	116	210
20	1126	2060	2655	15	2680	35	30	12	2822	6	2885	10	30	3008	79	140	217
104	1175	--	2714	36	2780	38	32	4	2908	14	2976	6	30	3106	50	104	210
21	1154	2062	2650	22	2698	31	34	4	2823	6	2880	8	28	3015	68	125	201
22	1135	2052	2624	24	2662	34	30	6	2796	6	2852	6	31	2986	80	100	217
162	688	1362	--	0	2002	26	12	--	--	0	2150	8	20	2275	72	139	100
156	685	1345	--	0	1983	44	--	--	--	0	2122	5	20	2248	108	170	177
169	697	--	--	0	2006	26	18	--	--	0	2152	6	22	2304	102	152	130
171	703	1375	--	0	2004	22	20	--	--	0	2158	4	30	2273	113	156	147
22-L[1]	576	1155	--	0	1875	32	35	--	--	0	2045	10	25	2170	107	135	209(?)
D-21[1]	621	1188	--	0	1927	57	--	--	--	0	2128	--	40	2316	74	74	114(?)
11[1]	715	1367	2065	55	2148	79(?)	--	--	--	0	--	--	--	2446	49	--	183(?)
14[1]	585	1175	1898	33	1957	19	18	--	--	0	2107	9	16	2258	59	79	154(?)
17[1]	581	1163	1854	26	1903	30	25	--	--	0	1873	8	20	2182	95	148	204(?)
33	643	1280	1996	12	2036	34	44	--	--	0	2218	8	24	2348	82	148	204
56[1]	627	1250	1984	25	2062	73	--	--	--	0	2227	--	10	2431	51	72	159(?)
65[1]	646	1285	2005	35	2060	47	28	--	--	0	--	--	--	2380	62	62	172(?)
81	649	1274	1995	35	2057	38	32	--	--	0	2219	6	22	2351	103	159	236
109	640	1246	1878	38	2042	34	36	--	--	0	2212	6	22	2338	72	108	208
115	633	1252	1982	38	2048	30	34	--	--	0	2226	6	14	2352	78	108	200
142	701	1360	--	0	2032	30	30	--	--	0	2194	8	26	2320	102	150	196
179	677	--	--	0	1948	32	22	--	--	0	2094	8	22	2316	102	140	166
24	1125	2245	2850	20	2890	40	28	10	3041	9	3108	8	24	3216	66	138	205
30	880	2056	2642	28	2684	40	32	14	2810	8	2888	8	28	3026	52	86	210

[1] Log based on core or sample description.
[2] Consists of two beds.

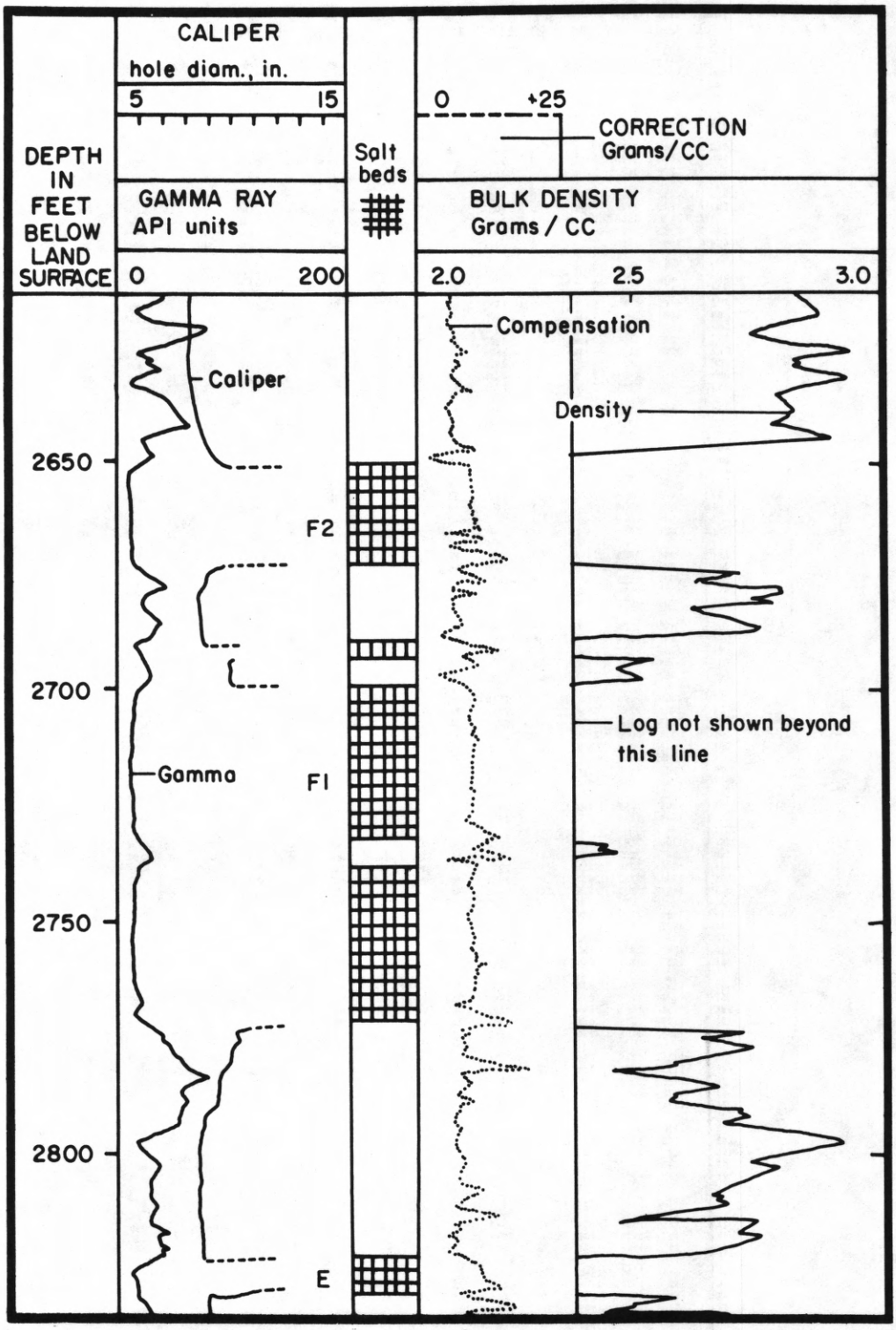


Figure 3.--Gamma, caliper, and compensated density logs of a well in Geauga County showing how salt beds were identified. (Log from files of Ohio Division of Geological Survey.)

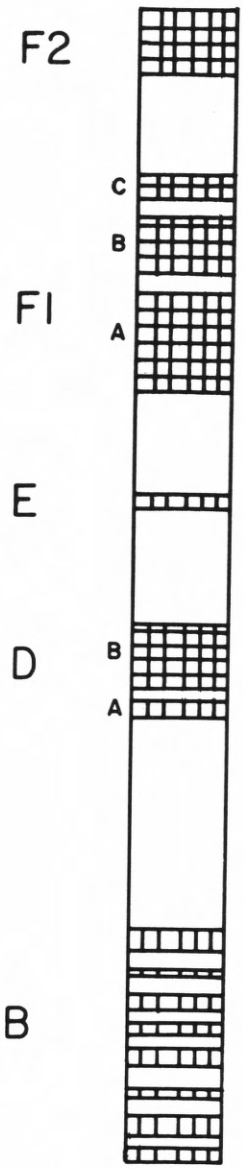
Salt beds	Description
	
F2	Average thickness is 24 feet; maximum thickness is 38 feet.
C, B, F1, A	Consists of three salt beds; average aggregate thickness of all three beds is 78 feet. Average thickness of interval extending from the bottom of F1A to the top of F1C is 91 feet. F1A is the thickest of the three beds, ranging in thickness from 22 to 46 feet and averaging about 35 feet.
E	General thickness is 4 or 5 feet; range in thickness, 2 to 14 feet.
D, B, A	Consists generally of two salt beds, separated by 4 to 6 feet of rock. DA is 6 to 10 feet thick; DB is 20 to 30 feet thick. Maximum thickness of DB is 34 feet.
B	As many as ten salt beds, ranging generally in thickness from 5 to about 15 feet; maximum single bed thickness is 22 feet. Salt beds are separated by beds 1 to 19 feet thick of dolomite and dolomite shale with salt inclusions. The salt beds average 67 feet in aggregate thickness and the interval extending from the base of the lowest salt to the top of the uppermost salt averages 107 feet.

Table 2.--General description of the salt beds.

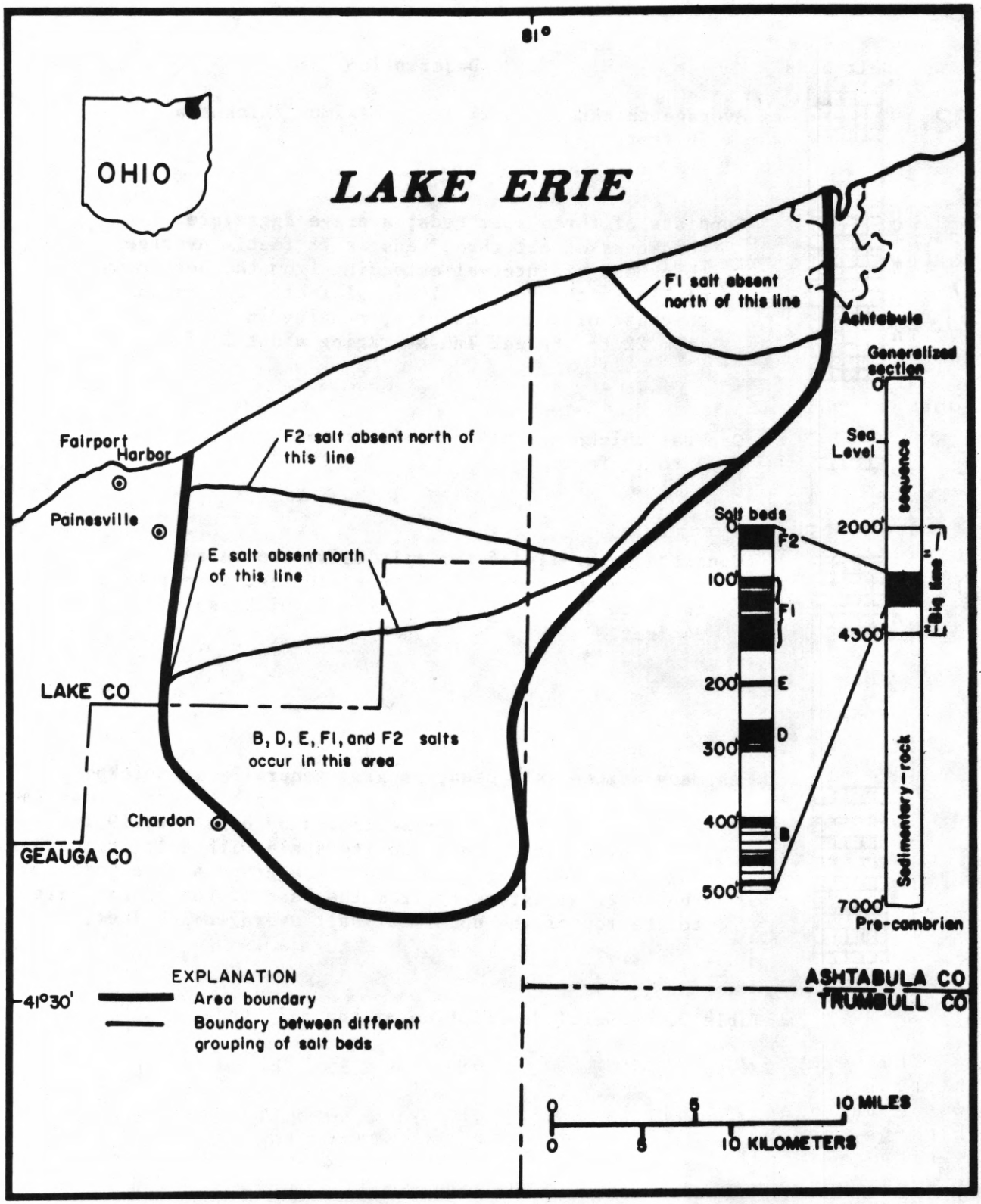


Figure 4.--Occurrence of salt beds.

southern part of the area and the southerly dip of the strata.

The sedimentary rocks dip southeastward about 25 feet per mile, as shown by structure contour maps on the surfaces of the "Big lime," figure 5, and the F1A salt, figure 6.

The stratigraphic interval between the base of the lowest salt and the top of the highest salt thickens southwestward from about 300 feet to about 475 feet (figure 7).

The salt beds, exclusive of the intervening rocks, also increase in thickness southward, from about 100 feet in the northeastern part of the area to about 250 feet in the southern part (figure 8).

CHARACTER OF THE SALT BEDS

A general description of the salt beds from literature sources is given by Norris, 1978. Additional descriptions, based on logs and core data from the oil and gas wells listed in table 1, are presented here and summarized in table 2. The locations of the wells are shown in figure 2.

B salts

The log of a core from well No. 17 (table 1 and fig. 2) drilled near Painesville lists 10 salt beds, all described as "dirty salt," ranging from 5 to 16 feet each in the B salt interval. The salt beds are separated by 2 to 19 feet of dolomite and dolomitic shale containing "some salt."

Another core description, from well No. 561, 10 miles southwest of Ashtabula, lists 9 salt beds in the B zone, of which one is 22 feet thick; the others range in thickness from 4 to 10 feet. The intervening beds, consisting of dolomite and dolomitic shale, range in thickness from a little more than a foot to 16 feet.

The exact thicknesses of the salt beds in the B salt interval are difficult to determine from the geophysical logs, but individual beds appear to be less than 15 feet thick in most wells. For the entire area, the B salts average 67 feet in aggregate thickness and the interval between the top and bottom of the B salt, including the intervening beds, averages 107 feet.

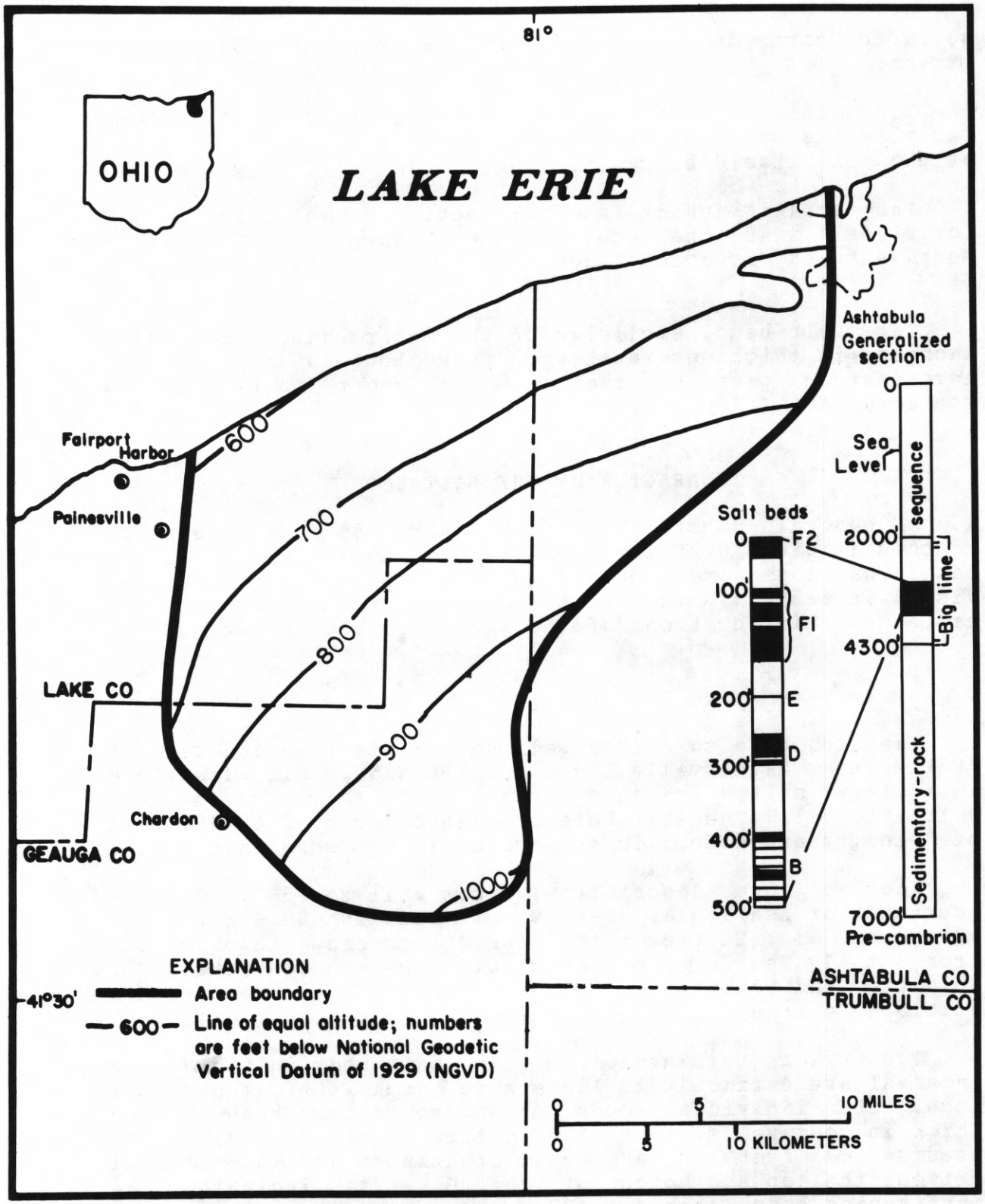


Figure 5.--Structure contours on the upper surface of the "Big lime".

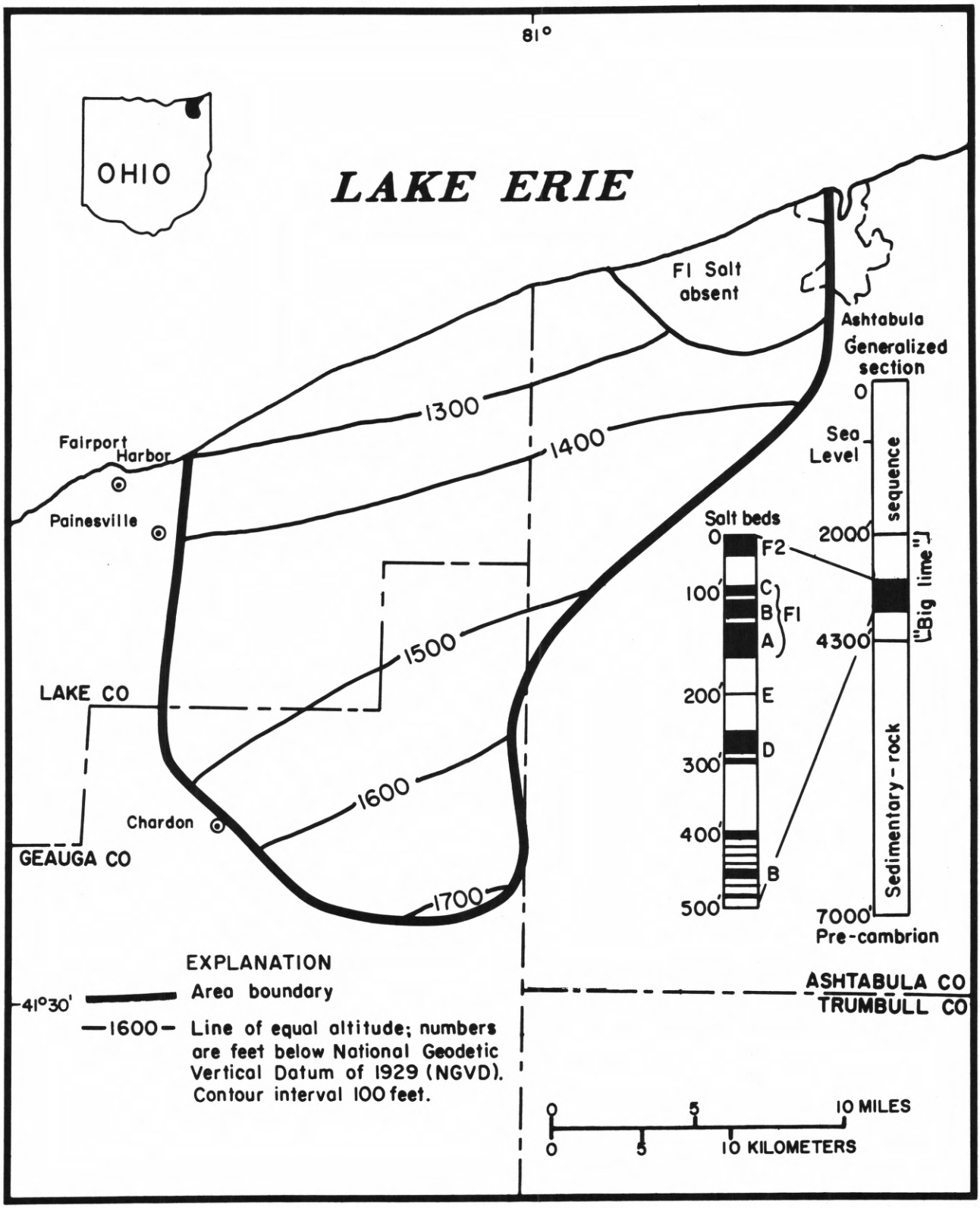


Figure 6.--Structure contours on the upper surface of the F1A salt bed.

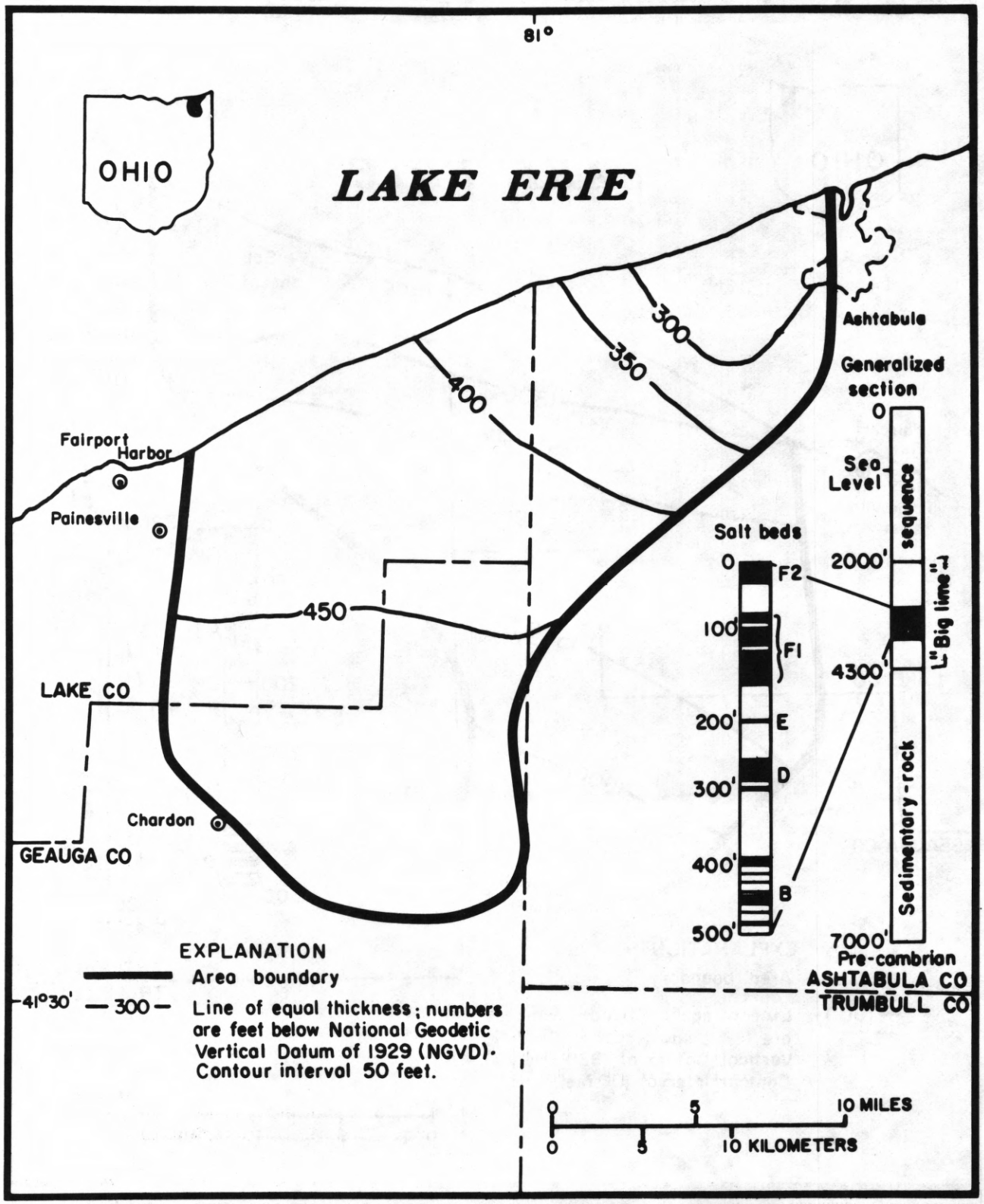


Figure 7.--Thickness of the stratigraphic interval between the base of the lowest salt and the top of the highest salt.

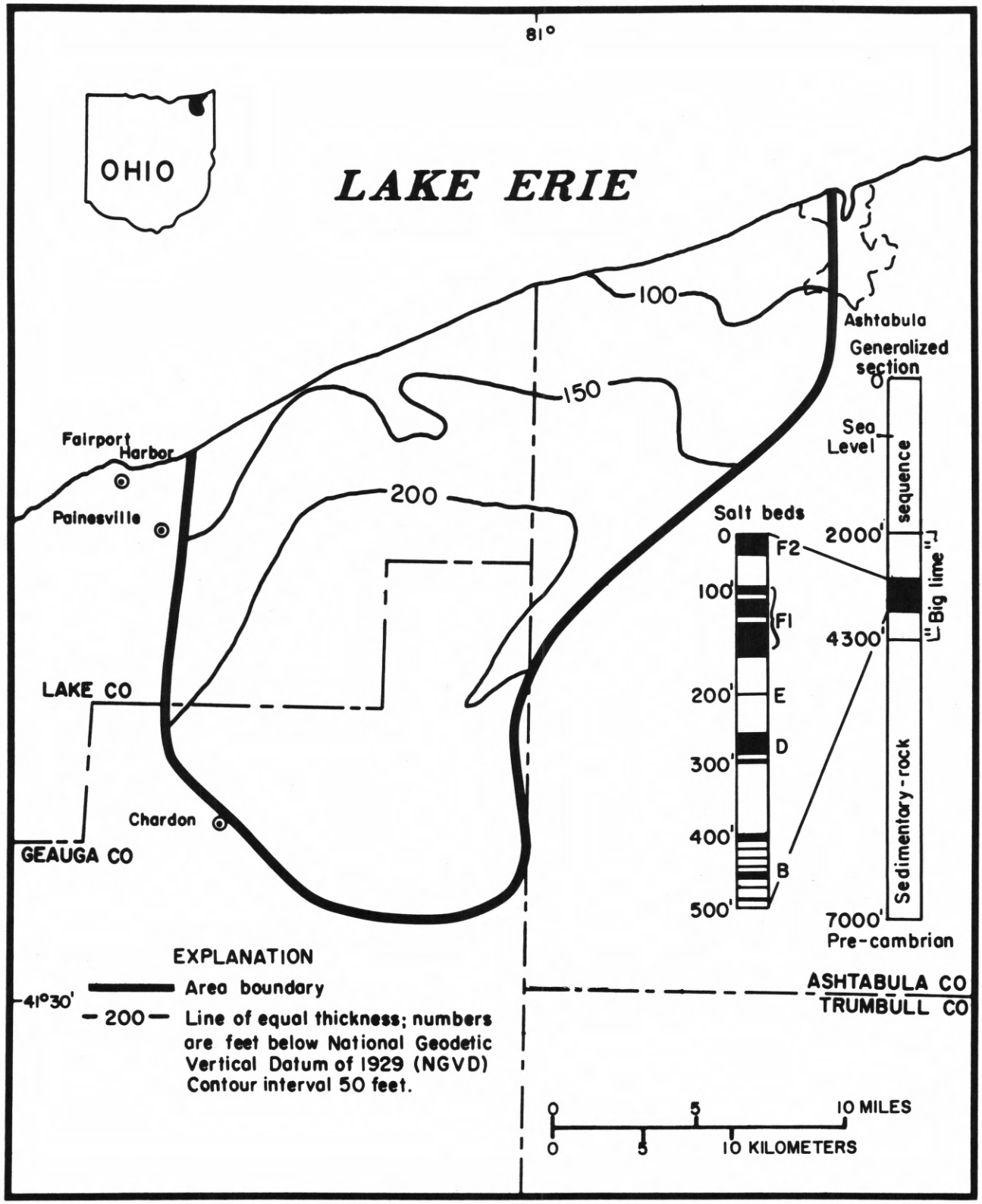


Figure 8.--Aggregate thickness of the salt beds (intervening rocks not included).

D salts

The D salts, 80 to 110 feet above the B salts, consist generally of two beds, separated by 4 to 6 feet of rock. The lower bed, designated DA, is 6 to 10 feet thick and the upper bed, DB, is 20 to 30 feet thick in much of the area. The maximum thickness of bed DB is 34 feet in well 576, about 10 miles south of Ashtabula.

E salt

The E salt is a single bed 2 to 14 feet thick; the thickness, generally, is 4 or 5 feet.

F1 salts

The principal salt sequence in the area of interest, and the one most likely to be considered for further investigation as a possible repository for nuclear waste, is the F1 salts. In much of the area the F1 salts consist of three individual salt beds, designated, in ascending order, F1A, F1B, and F1C. Salt F1A, the thickest of the three, ranges from 22 to 46 feet and averages about 35 feet in thickness. The average aggregate thickness of all three salt beds is 78 feet. The stratigraphic interval in which these beds occur; that is, the interval extending from the bottom of F1A to the top of F1C, averages 91 feet.

In parts of Ashtabula and Lake Counties the F1 salt consists of only two salt beds and in some places only one. Reduction in the number of salt beds is not accompanied, generally, by an increase in thickness of the remaining beds. The thickest single bed is 66 feet thick, in well 485. This well is about 10 miles south of Ashtabula and 2 miles east of the area of interest.

The depth to the F1A salt can be determined, approximately, from figures 1 and 6. At a given site the altitude of the land surface (figure 1) can be added to the corresponding altitude (below sea level) of the F1A salt (fig. 6). Consider, for example, a site in the vicinity of Chardon. Here the surface altitude, as shown in figure 1, is about 1,200 feet. The altitude of the F1A salt bed at this site, shown in figure 6, is about 1,550 feet below National Geodetic Vertical Datum of 1929 (NGVD); (formerly mean sea level). The depth to the F1A salt, therefore, is approximately 2,750 feet.

F2 salt

The stratigraphically highest salt is the F2 salt, which is present only in the southern half of the area (fig. 4). Near its northern terminus, the salt is about 450 feet above the base of the lowest (B) salt (see figs. 4 and 7). The F2 salt consists, generally, of a single bed 24 feet in average thickness. The greatest thickness is 38 feet, in wells 109 and 115, located about 4 miles south of Painesville and 2 miles west of the area of interest.

SELECTION OF SITES FOR TEST DRILLING

The most favorable area for test drilling, based on the maximum number of salt beds present (fig. 4), and the greatest aggregate thickness of the salt beds (fig. 8), is the southern half of the area of interest. All salts listed in table 2 occur in this part of the area and their thicknesses are near maximum. For example, the thickness of the F1A salt, the thickest single bed of the entire salt sequence, is an estimated 35 to 38 feet here. The aggregate thickness of all the salt beds is estimated at about 215 feet but may be as much as 230 feet locally (see table 1, well 197).

The work that remains to be done to select the best drilling site is a field investigation to locate population centers, cultural works, natural features, and a suitable terrain for drilling.

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