MICHIGAN BACKGROUND SOIL SURVEY 2005

Hazardous Waste Technical Support Unit
Hazardous Waste Section
Waste and Hazardous Materials Division

Michigan Background Soil Survey 2005

Introduction

In 1991, the Michigan Department of Natural Resources (MDNR) released a compilation of soil sampling data that represented what is assumed to be the naturally occurring background concentration of metals in Michigan soils. The data was presented in the "Michigan Background Soil Survey" (MBSS) dated April 1991. Since that time, additional soil sampling data from locations that represent background conditions has been collected, and the MBSS has been updated by the Michigan Department of Environmental Quality (MDEQ).

History

During the mid-1980s, closure plans were submitted to the state pursuant to cleanups and corrective action work at regulated hazardous waste treatment, storage, and disposal facilities. In order to assure that soil removal performed to get a clean closure was accomplished, standards were established that mandated the removal of contaminants until concentrations were nondetectable or within the naturally occurring background range. Therefore, facilities undergoing closure or corrective action for metals were required to submit analyses of soil from their specific location to determine the criteria to be met, which is statistically equivalent to the local, unimpacted background conditions. In order to evaluate the validity of these site-specific background values, a Michigan soil background database was compiled. That background soils database included information gathered by regulated facilities, as well as samples collected and analyzed by the state.

Background soil data from the regulated facilities has been obtained using standard sampling and analytical techniques at the time of collection, which were approved by the state, usually as part of a closure plan or remediation efforts. Common analytical methods from EPA/SW-846 were used (EPA method 200.7, SW-846 method series 6000/7000, etc.). Samples collected by the state were analyzed by an approved contract laboratory, or through the State of Michigan Environmental Laboratory. Some data was included from United States Geological Survey (USGS) and the Army Corp of Engineers. All results represent a total (available) metals analysis.

Data Reduction

The background soil data for each metal has been reviewed in two basic ways. The first is looking at the data by general soil type. Based usually on a visual observation, and occasionally a soil classification system, soil samples were divided into the following general soil types: topsoil, clay, sand & silt, or sand. The other breakdown was by geographic location, using glacial geology distinctions. In Michigan there were several different glacial ice sheets (lobes) that covered distinct areas. The glacial lobes have varying points of origin and traverse differing types of bedrock, and thus the resulting glacial sediments could have varying chemical characteristics based on source rock influences. Summary statistics are presented for general soil types and broad geographic areas based on the location of major glacial lobes.

Since the data comes from investigations at different sites, each with various parameters of concern, the suite of metals analyzed was not the same in each case. Depending on how

common the metal was a pollutant of concern, and the number of samples taken for site-specific background determinations, each metal will have a different total number of individual samples and number of sites.

Statistics

A basic statistical analysis was performed for each metal represented in the database. First, the percentage of nondetect values was determined, followed by analysis of the underlying distribution of the data. Finally, summary statistics such as the mean, median, standard deviation, quantiles and the range of concentrations for a metal were calculated with normal, lognormal, or nonparametric methods as appropriate.

In terms of detection limits, metals with 0 – 15 % nondetect results had a value equal to one half (1/2) of the respective detection limit substituted for calculation of summary statistics (Al, As, Ba, Ca, Cr, Cu, Fe, Mg, Mn, K, Na, Sr, Ti, V, Zn). Metals that have 15 - 50% nondetect values had summary statistics calculated using Cohen's adjustment (Li, Ni, Pb). For metals with over 50% nondetects, a nonparametric method was used (Ag, Be, Cd, Co, Hg, Mo, Sb, Se, Tl).

The data distribution was analyzed using graphical techniques (histogram, probability plot, box plot) and the Shapiro-Francia or Shapiro-Wilk Goodness-of-Fit test. For simplicity's sake, only normal or lognormal distributions were checked and the best fit to the respective metals' data was chosen. Subsequently, summary statistics were calculated as appropriate for a normal, lognormal, or nonparametric distribution. Tables are attached that list the summary statistics for each metal.

Summary

It is important to understand that the data and statistical summaries in the MBSS are to be used only for comparative purposes. The MBSS is meant to provide a resource for information regarding the concentration of naturally occurring metals that can be expected in various soil types and geographic areas of Michigan. Site-specific data is recommended to get the best representation of a local background concentration. This data is not to be used for setting site-specific cleanup criteria.

Contact Information

If there are any questions, or a desire to obtain data, please contact those listed below:

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Attachments

Table 1……. General Information – all data combined
Tables 2, 3, 4…….Topsoil, Sand and Clay - typical range of concentrations
Figure 1…….All Sample Locations and glacial lobe boundaries
Figures 2, 3, 4……..Topsoil, Sand and Clay - sample locations

General Information

METAL	Number of samples	Percent Non-detect	Assumed Distribution of Data	{a} Mean (mg/kg)	{b} Standard Deviation	Median (mg/kg)	{c} Typical Range of data (mg/kg)
Aluminum (Al)	295	0 %	Lognormal	3215	2.291	3420	2603 - 16,324
Antimony (Sb)	35	94 %	Nonparametric	--	--	< 5	< 0.04 – 2.5
Arsenic (As)	926	3 %	Lognormal	3.6	2.829	3.8	0.47 - 27.7
Barium (Ba)	463	1 %	Lognormal	31	2.707	38	4 - 220
Beryllium (Be)	128	77 %	Nonparametric	--	--	< 0.5	< 0.2 - 1.8
Cadmium (Cd)	535	72 %	Nonparametric	--	--	< 2	< 0.05 - 2.5
Chromium (Cr)	595	9 %	Lognormal	8.8	2.559	10	1.4 - 55
Cobalt (Co)	265	60 %	Nonparametric	--	--	< 5	< 3 - 12
Copper (Cu)	580	8 %	Lognormal	7.4	2.565	10	1 - 58
Iron (Fe)	266	0 %	Lognormal	5403	2.565	5645	852 - 34,233
Lead (Pb)	682	21 %	Censored-Log	7.1	2.562	7.73	1 - 45
Lithium (Li)	259	30 %	Censored-Log	3.8	3.373	3.5	0.35 - 41
Magnesium (Mg)	86	0 %	Lognormal	1360	4.837	824	62 - 29,875
Manganese (Mn)	326	0 %	Lognormal	139	3.235	190	14 - 1391
Mercury (Hg)	431	83 %	Nonparametric	--	--	< 0.1	< 0.025 - 0.6
Molybdenum (Mo)	100	100 %	--	--	--	< 5	< 5
Nickel (Ni)	492	23 %	Censored-Nor	12.3	13	11	2.4 - 39
Selenium (Se)	430	82 %	Nonparametric	--	--	< 0.5	< 0.05 - 1.2
Silver (Ag)	202	84 %	Nonparametric	--	--	< 0.5	< 0.2 - 2
Sodium (Na)	82	10 %	Normal	101.5	46.5	98	8.5 - 194.5
Strontium (Sr)	39	0 %	Nonparametric	--	--	100	30 - 150
Thallium (Tl)	90	86 %	Nonparametric	--	--	< 1	< 0.08 - 3.8
Titanium (Ti)	68	0 %	Normal	124	46.4	112	31 - 217
Vanadium (V)	122	1 %	Lognormal	12.5	2.729	10.9	2 - 89
Zinc (Zn)	582	3 %	Normal	33	21.1	32	2.5 - 75

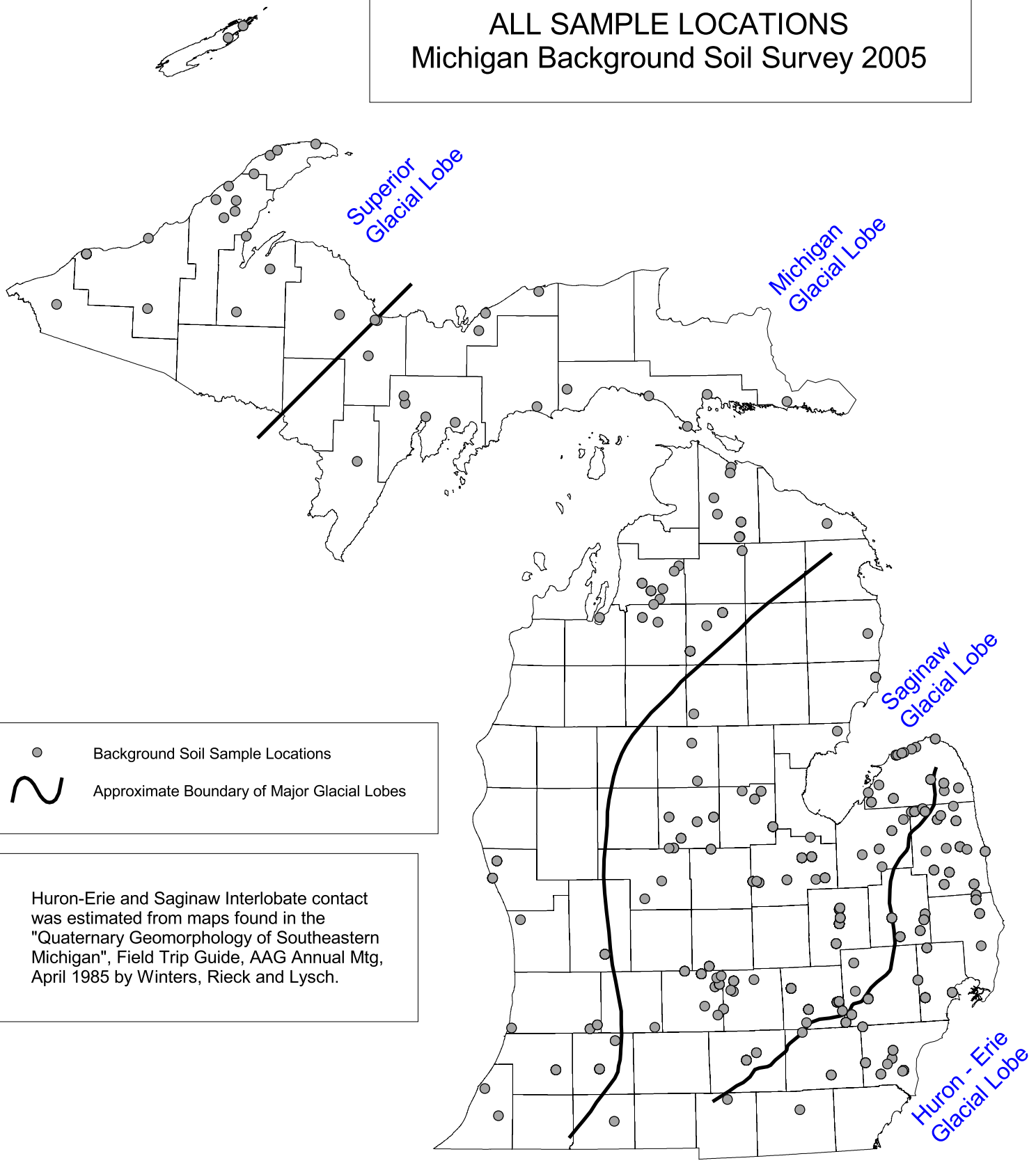
{a} For lognormal distributions, this represents the geometric mean. For normal distributions this represents the arithmetic mean. The mean was not estimated for data with non-parametric distributions (greater than 50% non-detect).

{b} For lognormal distributions, this represents the geometric standard deviation. The standard deviation is not estimated for data with non-parametric distributions.

{c} Typical range given is the central 95% of the data, or two standard deviations, calculated using the appropriate normal or lognormal formulas. The non-parametric range is based on the 2.5 and 97.5 quantiles of the data set.

TABLE 1

ALL SAMPLE LOCATIONS
Michigan Background Soil Survey 2005



Huron-Erie and Saginaw Interlobate contact was estimated from maps found in the "Quaternary Geomorphology of Southeastern Michigan", Field Trip Guide, AAG Annual Mtg, April 1985 by Winters, Rieck and Lysch.

TOPSOIL

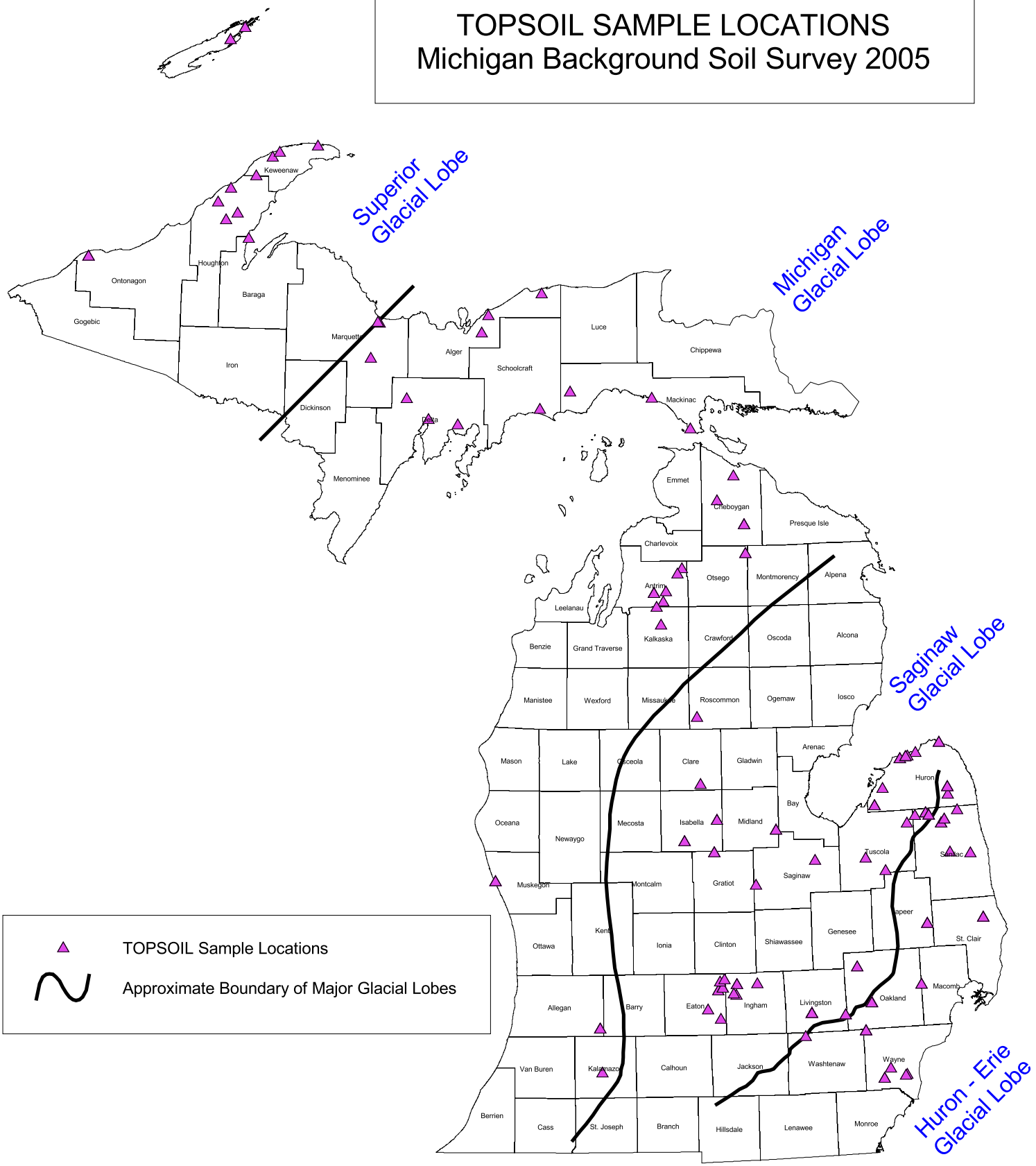
	Dist.	Glacial Lobe Area												Statewide						
		HURON - ERIE			SAGINAW			MICHIGAN			SUPERIOR			TOPSOIL - Combined Statewide Data						
		n	x	SD	n	x	SD	n	x	SD	n	x	SD	n	min	max	x	SD	1 SD	2 SD
Al	L	10	4572	1.467	37	2740	2.172	34	1112	1.724	16	3055	2.448	97	340	9950	2144	2.34	5017	11347
Sb	non	0	--	--	0	--	--	0	--	--	0	--	--	0	--	--	--	--	--	--
As	L	47	5.67	1.652	93	2.39	2.394	39	1.09	2.10	18	1.36	1.69	197	< 0.5	34	2.4	2.552	6.1	15
Ba	L	15	37.7	2.614	42	26.2	1.748	39	14.2	2.225	16	37.3	2.125	112	2.2	10.	23.4	2.284	53.4	118
Be	non	2	< 0.2	--	12	< 0.3	--	0	--	--	0	--	--	14	< 0.2	0.4	< 0.3	--	0.3	0.37
Cd	non	15	< 2	--	42	< 2	--	38	< 2	--	18	< 2	--	113	0.12	2	<2	--	< 2	< 2
Cr	L	15	12.9	1.718	45	7.2	2.164	39	2.8	1.938	18	7.274	2.273	117	1	36	5.7	2.426	13.8	32
Co	non	10	< 5	--	29	< 5	--	32	< 5	--	16	> 5	--	87	< 5	14	< 5	--	< 5	7
Cu	L	15	10.1	2.410	42	4.7	2.462	39	2.7	2.259	18	28.1	2.522	114	< 1	82.5	5.7	3.267	18.6	58
Fe	L	10	9547	1.503	42	4953	2.563	38	2432	1.91	18	4722	2.297	108	320	22300	4065	2.431	9882	23185
Pb	L	38	11.7	1.931	60	7.8	2.147	39	7.4	1.854	18	11.4	2.587	155	2.3	66.2	8.8	2.149	18.9	39
Li	L	10	4.5	1.559	34	2.9	2.292	32	< 2	--	18	2.8	1.990	94	2	12	2.2	2.363	5.2	12
Mg	L	2	1576	1.245	8	2281	2.332	0	--	--	0	--	--	10	490	8900	2119	2.152	4560	9517
Mn	L	10	475	2.158	42	124	3.065	38	117	3.113	18	136	2.718	108	3	1500	140	3.116	436	1299
Hg	non	15	< 0.1	--	42	< 0.1	--	38	< 0.1	--	18	< 0.1	--	113	<0.05	0.5	< 0.1	--	< 0.1	0.24
Mo	--	2	< 5	--	12	< 5	--	0	--	--	0	--	--	14	< 1	< 5	--	--	< 5	< 5
Ni	L	11	8.8	1.501	42	5.6	1.740	38	< 5	--	18	7.4	3.157	109	5	47	4.4	2.424	10.7	25
Se	non	22	< 1	--	42	< 0.5	--	38	< 0.5	--	18	< 0.5	--	120	<0.05	8	< 0.5	--	< 0.5	1.3
Ag	non	6	< 0.25	--	5	< 0.25	--	0	--	--	0	--	--	11	< 0.2	1.7	< 0.25	--	< 0.25	1.3
Na	N	2	125	--	5	92	24.6	0	--	--	0	--	--	7	65	130	101	25.9	127	153
Sr	non	0	--	--	7	106	--	0	--	--	0	--	--	7	73	157	106	--	148	156
Tl	non	2	< 1	--	5	< 1	--	0	--	--	0	--	--	7	< 1	< 1	< 1	--	< 1	< 1
Ti	N	2	94.5	9.2	12	133	43.9	0	--	--	0	--	--	14	73	210	127.4	42.8	170	213
V	L	2	20.9	1.145	12	14.1	1.483	0	--	--	0	--	--	14	8	28	14.9	1.48	22	32
Zn	N	23	43.2	17.9	45	28.1	16.6	39	13	7.2	18	42.9	28.5	125	< 5	99	28.3	20.7	49	70

Dist. = Distribution of data (L~ Lognormal, non ~ nonparametric, N ~ Normal).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg)

Data Range	Lognormal	Normal	Nonparametric
1 SD	(x)(SD)	x + (1)SD	84^{th} quantile
2 SD	$(x)(SD)^{1.96}$	x + (2)SD	97.5 quantile

TABLE 2

TOPSOIL SAMPLE LOCATIONS
Michigan Background Soil Survey 2005



SAND

	Dist.	Glacial Lobe Area												Statewide						
		HURON - ERIE			SAGINAW			MICHIGAN			SUPERIOR			SAND - Combined Statewide Data						
		n	x	SD	n	x	SD	n	x	SD	n	x	SD	n	min	max	x	SD	1 SD	2 SD
Al	L	2	1699	1.171	54	2339	1.952	34	2624	1.816	3	1230	1.102	93	260	16400	2373	1.891	4487	8272
Sb	non	1	6.45	--	3	< 1	--	3	< 1	--	0	--	--	7	< 1	6.45	< 1	--	2.7	5.9
As	L	34	3.42	2.437	118	2.6	3.244	53	1.25	2.645	3	< 1	--	208	< 0.4	40	2.2	3.139	6.9	20.7
Ba	L	22	75.2	2.914	71	12.4	2.014	51	16.6	2.052	3	5.6	1.073	147	2.6	200	17.7	2.693	47.7	123
Be	non	3	< 0.2	--	51	< 0.2	--	6	< 1	--	0	--	--	60	< 0.2	0.645	< 0.2	--	< 1	0.37
Cd	non	22	< 2	--	67	< 2	--	39	0.11	--	3	< 2	--	131	<0.01	2.1	< 2	--	< 2	1.8
Cr	L	22	4.0	2.29	90	5.2	1.986	67	3.9	2.209	3	8.6	1.372	182	1	50	4.6	2.125	9.8	20.2
Co	non	2	< 5	--	61	< 5	--	16	< 5	--	3	< 5	--	82	< 3	8.7	< 5	--	< 5	7
Cu	L	22	6.3	2.204	90	3.2	2.484	67	3.5	2.596	3	4.1	1.197	182	0.4	28	3.6	2.523	9.1	22.1
Fe	L	2	4247	1.051	55	3612	2.192	17	3418	1.88	3	3023	1.108	77	99.5	20400	3559	2.063	7342	14715
Pb	L	25	4.7	2.358	95	2.9	2.963	52	3.9	3.230	3	< 5	--	175	1.0	30	3.5	2.906	10.2	28.3
Li	L	2	< 2	--	62	2.3	2.223	11	2.2	3.333	3	< 2	--	78	< 2	20	2.14	2.402	5.1	11.9
Mg	L	2	840	1.017	44	871	4.09	13	671	1.759	0	--	--	59	35	28000	821	3.471	2850	9411
Mn	L	2	41	1.071	62	50.3	3.809	24	107	3.649	3	36.7	1.178	91	1	1500	60.5	3.773	228	817
Hg	non	17	< 0.04	--	66	< 0.05	--	22	0.03	--	3	< 0.1	--	108	<0.018	0.62	<0.05	--	< 0.1	0.08
Mo	--	2	< 5	--	51	< 5	--	6	< 5	--	0	--	--	59	< 5	< 5	< 5	--	< 5	< 5
Ni	L	8	9.3	1.875	78	4.8	2.185	40	4.0	2.175	3	<5	--	129	1.2	34	4.6	2.243	10.3	22.4
Se	non	18	< 0.4	--	62	<0.5	--	20	<0.5	--	3	<0.5	--	103	<0.05	1.5	< 0.5	--	<0.5	0.56
Ag	non	8	<1	--	48	<0.5	--	13	0.017	--	0	--	--	69	<0.01	0.71	<0.25	--	<0.5	0.66
Na	N	2	140	14.1	44	81	42.5	12	123	22.5	0	--	--	58	25	210	92	42.9	135	178
Sr	non	0	--	--	7	50	--	6	70	--	0	--	--	13	30	150	70	--	104	150
Tl	non	3	<0.5	--	46	< 1	--	9	<0.086	--	0	--	--	58	<0.5	6.13	< 1	--	< 1	5
Ti	N	2	186	10.6	44	121	43.2	0	--	--	0	--	--	46	13	227	124	44.4	168	213
V	L	2	9	1	51	8.9	2.693	19	9.4	2.226	0	--	--	72	0.05	98	9	2.519	22.7	55
Zn	N	22	27	19.4	80	17	15.5	64	18.2	16.6	3	6.3	0.29	169	1.3	95	19	16.9	36	53

Dist. = Distribution of data (L~ Lognormal, non ~ nonparametric, N ~ Normal).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg).

Data Range	Lognormal	Normal	Nonparametric
1 SD	(x)(SD)	x + (1)SD	84^{th} quantile
2 SD	$(x)(SD)^{1.96}$	x + (2)SD	97.5 quantile

SAND SAMPLE LOCATIONS
Michigan Background Soil Survey 2005

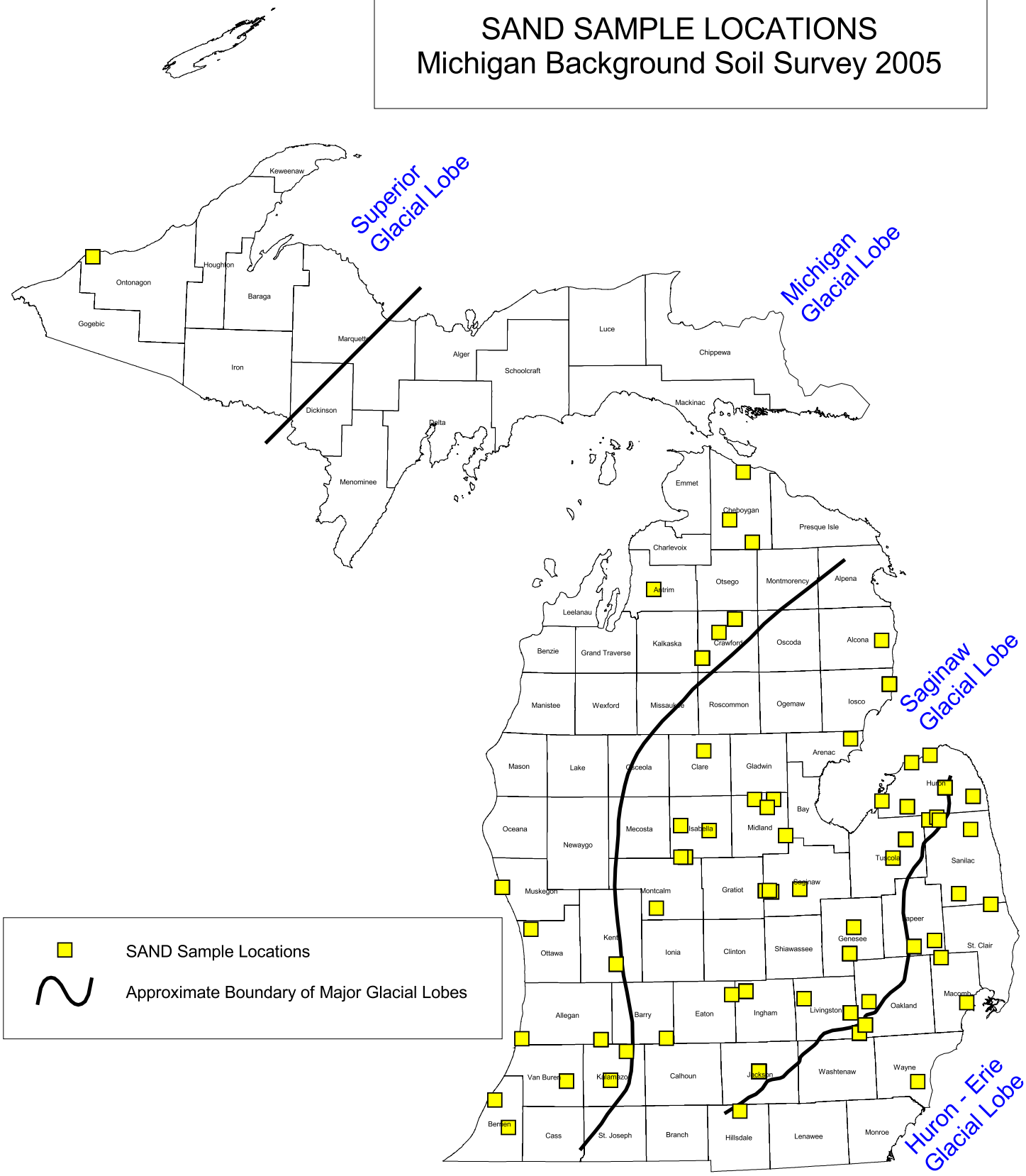


FIGURE 3

CLAY

	Dist.	Glacial Lobe Area												Statewide						
		HURON - ERIE			SAGINAW			MICHIGAN			SUPERIOR			CLAY - Combined Statewide Data						
		n	x	SD	n	x	SD	n	x	SD	n	x	SD	n	min	max	x	SD	1 SD	2 SD
Al	L	23	8182	1.248	51	6862	1.428	6	8691	1.548	3	9490	1.131	83	1720	15570	7416	1.40	10382	14341
Sb	non	8	6	--	0	--	--	12	<0.04	--	0	--	--	20	<0.04	7.2	<0.4	--	6.2	6.9
As	L	126	9	2.047	224	4.7	1.978	17	2	1.888	3	2	1.077	370	0.2	88	5.6	2.201	12.3	26.3
Ba	L	104	74.2	1.959	48	44.9	1.577	6	49.5	1.592	3	94.7	1.032	161	6.8	291	63.2	1.906	120	224
Be	non	11	0.65	--	9	<0.2	--	12	<0.5	--	0	--	--	32	<0.2	1.82	0.275	--	0.7	1.6
Cd	non	128	< 2	--	108	< 2	--	16	<0.4	--	3	< 2	--	255	<0.12	4.7	< 2	--	1.5	2.9
Cr	L	107	22	1.708	111	14.3	1.626	17	10.1	1.521	3	27	1.038	238	< 5	70	17.1	1.753	30	51.4
Co	non	29	9.1	--	22	9	--	6	4	--	3	6.5	--	60	1.9	13	8.9	--	11	12.5
Cu	L	103	16.3	1.738	103	14.1	1.485	17	12.6	1.474	3	20.6	1.078	226	0.56	52	15	1.613	24	38.3
Fe	L	26	20110	1.107	24	15090	1.398	6	10120	1.603	3	10970	1.119	59	5000	26000	16180	1.419	22959	32127
Pb	L	126	9	1.859	125	9.7	2.770	17	12.1	2.017	3	< 5	--	271	1	32	10.1	2.076	21	42.3
Li	L	29	20.1	1.437	22	14.4	1.698	4	9.1	1.542	3	11	1.095	58	3.5	77	16.3	1.630	26.6	42.5
Mg	N	0	--	--	8	36690	13040	2	12450	16340	0	--	--	10	895	49000	31844	16324	48168	64492
Mn	L	29	343	1.508	52	277	1.463	6	182	1.554	3	256	1.097	90	84	730	288	1.515	436	650
Hg	non	97	<0.1	--	54	<0.1	--	5	<0.1	--	3	<0.1	--	159	<0.02	0.9	<0.1	--	0.19	0.63
Mo	--	3	< 3	--	9	<5	--	0	--	--	0	--	--	12	<3	<5	<5	--	<5	<5
Ni	N	100	25.8	9.6	105	19.9	8.4	6	15.4	8.8	3	20	1.73	214	2.5	53	22.6	9.5	32.1	41.6
Se	non	94	0.33	--	43	<0.5	--	16	<0.4	--	3	<0.5	--	156	<0.05	2.4	<0.5	--	< 1	0.72
Ag	non	61	0.6	--	28	<0.5	--	12	<0.4	--	0	--	--	101	<0.2	3.3	< 1	--	1	3.1
Na	N	0	--	--	8	170	38.5	2	164	22.6	0	--	--	10	110	220	169	34.9	204	239
Sr	non	3	150	--	1	100	--	0	--	--	0	--	--	4	70	150	125	--	150	150
Tl	non	8	0.6	--	8	< 1	--	1	<0.5	--	0	--	--	17	<0.5	0.72	< 1	--	0.64	0.69
Ti	N	0	--	--	8	123	67.3	0	--	--	0	--	--	8	42	210	123	67.3	190	258
V	L	4	104	1.886	9	20.6	1.756	2	16.8	1.95	0	--	--	14	6	150	28.3	2.437	69	162
Zn	N	126	52.6	15.25	97	35.9	14.91	6	23.8	11	3	30.7	3.22	232	8.4	140	44.6	17.4	62	79

Dist. = Distribution of data (L~ Lognormal, non ~ nonparametric, N ~ Normal).
n = number of samples.
x = arithmetic or geometric mean, nonparametric median (mg/kg).
SD = arithmetic or geometric standard deviation, not applicable for nonparametric.
min = minimum value in data set (mg/kg).
max = maximum value in data set (mg/kg).

Data Range	Lognormal	Normal	Nonparametric
1 SD	(x)(SD)	x + (1)SD	84^{th} quantile
2 SD	$(x)(SD)^{1.96}$	x + (2)SD	97.5 quantile

CLAY SAMPLE LOCATIONS
Michigan Background Soil Survey 2005

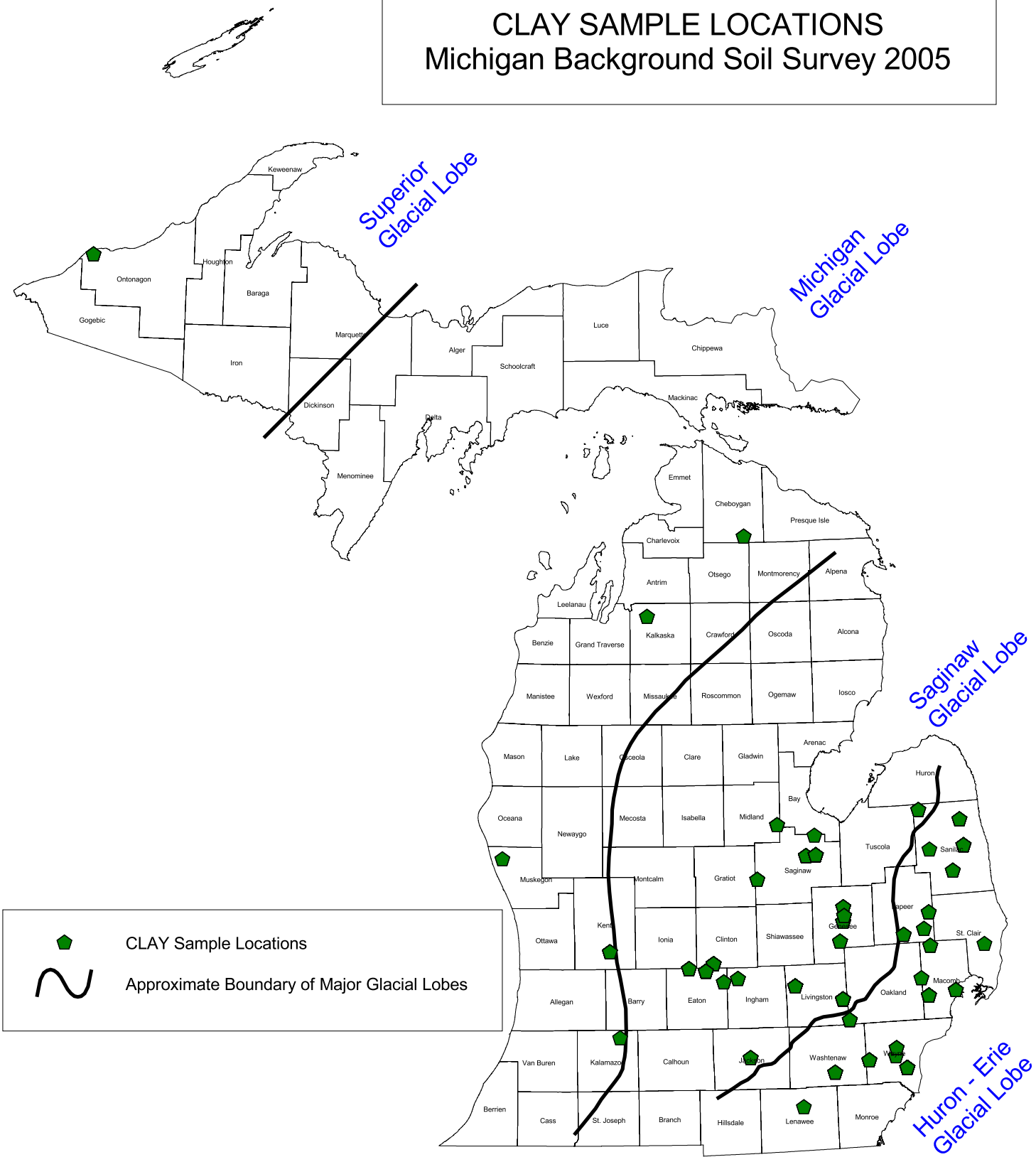


FIGURE 4