A Geochemical Atlas of Georgia

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Geologic Atlas 3

A GEOCHEMICAL ATLAS OF GEORGIA

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LIST OF PLATES

Note: Except where indicated, the plates show 100 percent of the points sampled for a particular variable.

1. NURE stream-sediment sample location of all points.
2. NURE stream-sediment supplementary data sample location of all points
3. Al (aluminum)
4. Au (gold)
5. Ba (barium)
6. Ce (cerium)
7. Co (cobalt)
8. Conductivity
9. Cr (chromium)
10. Cu (copper)
11. Cu (highest 10 percent of observations)
12. Dy (dysprosium)
13. Eu (europium)
14. Fe (iron)
15. Hf (hafnium)
16. K (potassium)
17. La (lanthanum)
18. Li (lithium)
19. Lu (lutetium)
20. Mg (magnesium)
21. Mn (manganese)
22. Na (sodium)
23. Nb (niobium)
24. Ni (nickel)
25. Ni (highest 10 percent of observations)
26. P (phosphorus)
27. Pb (lead)/ (highest 10 percent of observations)
28. pH
29. Sc (scandium)
30. Sm (samarium)
31. Sn (tin)
32. Sr (strontium)
33. Th (thorium)
34. Ti (titanium)
35. U (uranium)
36. U (highest 10 percent of observations)
37. V (vanadium)
38. W (tungsten)
39. Y (yttrium)
40. Yb (ytterbium)
41. Zn (zinc)
42. Zn (highest 10 percent of observations)

INTRODUCTION

This atlas is a set of maps that show concentrations of chemical elements in stream-sediment samples collected in north and central Gerogia. Analyses of stream-sediment samples represent the relative abundances of chemical elements in stream drainage basins, and therefore the maps are believed to portray regional concentrations of chemical elements. The original data were obtained by the U.S. Department of Energy (DOE) in its National Uranium Resources Evaluation (NURE) program; the elements were selected for their relation to program objectives.

The atlas maps are on a scale of 1:1,785,000 so that they can be used with the Geological Highway Map of the Southeastern Region (Bennison, 1975). Four different concentration groups are represented by different symbols. There are two kinds of maps; the first shows element concentrations at all of the sample points; the second shows the highest 10 percent of the points.

Seventeen elements, as well as pH and conductivity, were analyzed for the 6.038 samples sites plotted on plate 1. Fifteen additional elements were analyzed for the 2,949 of the original sites plotted on plate 2. Table 1 identifies the elements. Two hundred sixty-six samples were also analyzed for gold. Analyses were performed for four additional elements (including silver, arsenic, beryllium, and molybdenum) but are not included in the set of plates because of data quality.

Table 1, an alphabetical list of the elements, shows that the number of observations (number of reported analyses) is generally less than the number of sites, as is usual in regional geochemical surveys made using rapid, routine analytical methods. Also, for some elements, only a few observations are above the detection limit, because their analyses were done only incidentally to analyses for other elements. Besides the element means (arithmetic averages), the table lists the standard deviation (the usual measure of variability), the coefficient of variation (a measure of relative variability), and the crustal abundances of the elements. The table also lists two other variables, pH and conductivity.

THE DATA BASE

Between 1973 and 1979, DOE conducted the NURE program in all of the United States except Hawaii; the purpose was to evaluate uranium resources and to locate places favorable for uranium exploration. In the Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) phase of the program, stream sediments, ground water, and surface water were sampled. About two-thirds of the United States and about the same proportion of Georgia were sampled before the program was terminated. Four national laboratories conducted the HSSR program; the Savannah River Laboratory at Aiken, South Carolina conducted the Georgia program. Fay and others (1981) report the Georgia results in a publication that consists of a brief text and a microfiche listing of the field and analytical data. These data are also available on magnetic tape for computer processing. (The data were originally organized in two-degree quadrangles of the National Topographic Map Series; Fay and others [1981, p. 44] list the quadrangle names and original report numbers.)

Sampling was done by established exploration-geochemical procedures as explained in standard texts (for example, Rose, Hawkes, and Webb [1979, p. 431-454]); Fay and others (1981, p. 20) provide details. The Savannah River Laboratory prepared the samples and analyzed the original group of elements by automated neutron activation analysis. Contractors analyzed the supplemental elements by atomic absorption or other methods (Fay and others, 1981, p. 24-27). The results of the gold analyses, done later by neutron activation analysis, were reported separately by Fay and Cook (1982).

Some limitations of the data need to be explained. The survey objectives dictated broad coverage of a large area and a large number of variables; the data base for this report contains about 160,000 analyses at some 6000 sites. The sampling was done by trained workers but most were not professional geologists; the analytical work was done by automated procedures that changed over time. Program objectives emphasized overall coverage rather than individual sample points; therefore, the data provide reliable general patterns but only in some places identify particular geochemical phenomena. For instance, most high uranium values (plate 35) represent high concentrations of uranium-bearing minerals, but some may represent contamination. In addition, some high concentrations of uranium may not have yielded high values because of problems in sampling, sample preparation, analysis, or reporting. Fay and others (1981, p. 15, 20) explain some of these factors.

THE ATLAS MAPS

The maps are reproduced from computer-generated output made at the University of Georgia using a Cyber 750 computer and a Versatec electrostatic plotter. The computer program provides a Universal Transverse Mercator projection. The scale, map area, variable plotted, concentration boundaries and intervals, and pen colors (for plotters with color capability) can be specified by the map maker. Data lists and frequency distributions have been placed on open file (Koch, 1984).

The maps in this atlas are point maps. Each sample site is represented by a symbol, corresponding to a percentile class of 25 if all observations are plotted or 2.5 if 10 percent of them are plotted (for a few elements with many values at or near the detection limit, other intervals were used). An alternative type of map is a smoothed map in which the data are averaged in order to reduce local variability. Howarth and others (1980) compare the two kinds of maps and provide some illustrations of smoothed maps for part of northern Georgia.

USES OF THE ATLAS

Regional exploration geochemical data of the type presented in this atlas are often used for mineral exploration. In this work, sites with elemental concentrations sufficiently higher than average concentrations ("background") for an area or for a rock type are designated as "anomalous," and may indicate areas of mineralization. Generally, follow-up detailed geochemical sampling or other work is done to evaluate such areas. Different backgrounds are usually found in rock units with distinctive lithologies; Howarth and others (1980, p. 345) provide data for geologic provinces in Georgia. Sometimes the commodity of interest is sampled directly, for instance gold (plate 4); sometimes other elements termed "pathfinders" that are associated with the commodity of interest are sampled, for instance manganese for base-metal veins (Rose, Hawkes, and Webb, 1979, p. 28, 76).

Another use of exploration geochemical data is to identify areas with either favorable or unfavorable conditions for agriculture. Many trace elements — including cobalt, copper, chromium, iron, manganese, molybdenum, and zinc — must be present in soils within narrow limits for optimum agriculture. For instance, one area near Raytown, Georgia (the Shiloh Church molybdenum deposit) contains molybdenum in concentrations harmful to cattle (Murphy, 1982).

A similar use is to identify areas with trace element geochemistry favorable or unfavorable for human health, so that diets can be supplemented in unfavorable areas. For instance, it has been postulated that the well-known contrast in cardiovascular disease between northern and southern Georgia is due to trace element geochemistry (Shacklette and others, 1970).

Still another use of exploration geochemical data is to provide a baseline from which to appraise pollution at the time of the survey and to measure changes in trace elements in the environment through time.

Table 1. Stream-sediment geochemical data for Georgia. Group 1 is the original data set; Group 2 is the supplementary data set.

Group	Variable		No. of Samples Total	DL	DL	Mean	Std. Dev.	Coef. of Var.	Crustal Abund.
1	Al	pct	5713	5713		3.25	2.49	0.77	8.1
1	Au	ppm	266	266		0.72	1.86	2.58	.003
2	Ba	ppm	1073	1005	5.	66.8	95.0	1.42	580.
1	Ce	ppm	5786	5219	20.	295.4	591.5	2.00	81.
2	Co	ppm	2775	1557	5.	6.22	5.66	0.91	25.
1	Cond.	*	5902	5902		67.52	489.13	7.24	
2	Cr	ppm	2752	636	5.	4.58	5.99	1.31	100.
2	Cu	ppm	2949	1579	5.	6.33	6.10	0.96	50.
1	Dy	ppm	4632	4632		17.22	28.26	1.64	
1	Eu	ppm	4652	2149	1.	2.70	4.87	1.80	
1	Fe	pct	5791	5448	0.5	2.88	3.18	1.10	4.65
1	Hf	ppm	5830	5830		68.15	113.19	1.66	3.
2	K	ppm	2756	2677	0.1	1.17	0.90	0.77	250.00
1	La	ppm	5590	5590		163.23	324.51	1.99	25.
2	Li	ppm	2929	1977	5.	7.5	6.4	0.85	30.
1	Lu	ppm	5975	5105	0.3	1.41	2.03	1.44	
2	Mg	pct	2756	2722	0.02	0.18	0.12	0.68	1.7
1	Mn	ppm	5542	5542		782.3	1058.7	1.35	1000.
1	Na	ppm	5368	5368		0.39	0.59	1.53	300.
2	Nb	ppm	2933	1295	20.	23.16	24.95	1.08	20.
2	Ni	ppm	2949	1557	5.	6.41	5.88	0.92	75.
2	P	ppm	2918	2918		666.8	638.9	0.96	900.
1	pH		5902	5902		6.73	0.76	0.11	
1	Sc	ppm	5876	5876		7.19	6.96	0.97	13.
1	Sm	ppm	5554	5554		28.97	97.16	3.35	
2	Sn	ppm	2935	1632	5.	9.11	10.85	1.19	2.
2	Sr	ppm	1858	371	50.	37.1	32.5	0.88	300.
1	Th	ppm	5778	5778		56.62	112.59	1.99	10.
1	Ti	ppm	5338	5338		9626.6	9170.0	0.95	4400.
1	U	ppm	5851	5851		11.62	17.59	1.51	2.5
1	V	ppm	5646	5646		64.90	75.69	1.17	150.
2	W	ppm	2911	334	2.	1.34	1.65	1.23	1.
2	Y	ppm	2760	2760		42.1	61.4	1.46	
1	Yb	ppm	4367	4367		11.78	15.32	1.30	
2	Zn	ppm	2949	2838	5.	26.28	25.63	0.98	80.

* DL is detection limit; Cond. is conductivity in mmho/cm; Std. Dev. is standard deviation; Coef of Var is coefficient of variation; Crustal abund is crustal abundance. Crustal abundance data from Rose and others (1979, p. 30).

REFERENCES

Note: The Department of Energy reports are available on microfiche from the Bendix Field Engineering Corporation, Box 1569, Grand Junction, Colorado 81502, where they are cataloged under their GJBX numbers.

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Rose, A.W., Hawkes, H.E., and Webb, J.S., 1979, Geochemistry in mineral exploration: New York, Academic Press, 657 p.

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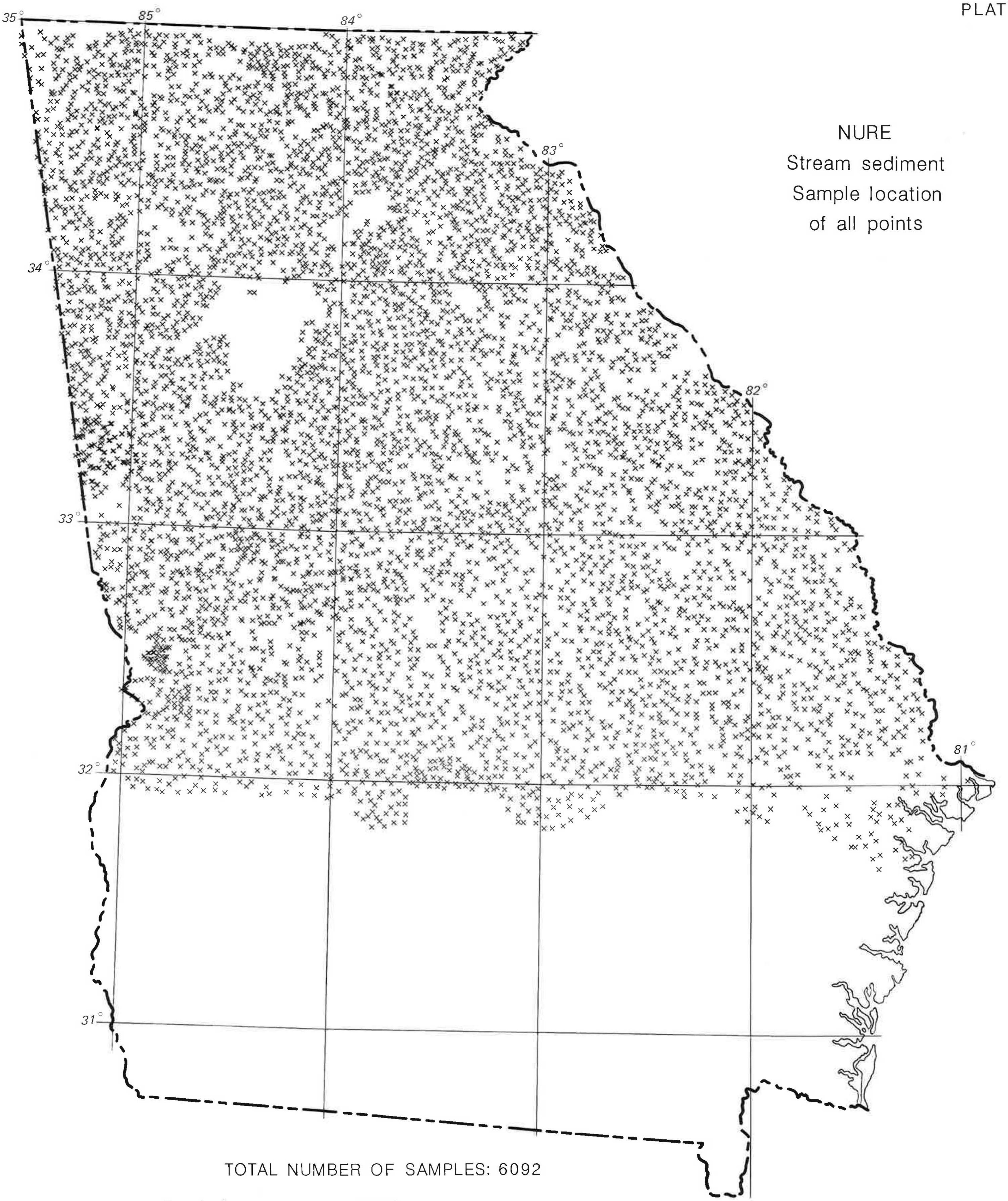
PLATE 1

NURE
Stream sediment
Sample location
of all points



TOTAL NUMBER OF SAMPLES: 6092

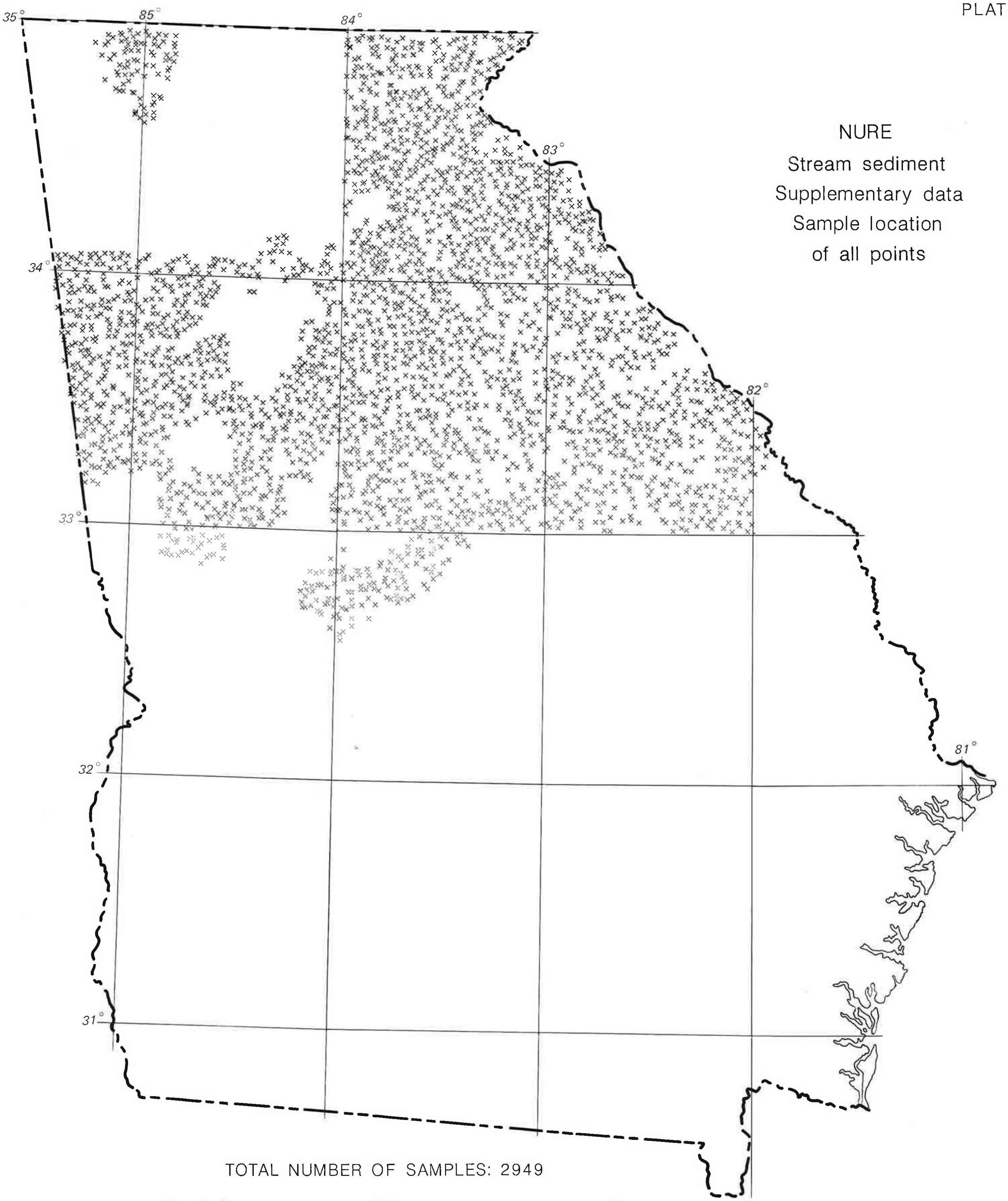
Symbol	PPM	Percent of data
*		25.0
+		25.0
Y		25.0
I		25.0

0 10 25 50 MILES

1:1,785,000

PLATE 2

NURE
Stream sediment
Supplementary data
Sample location
of all points



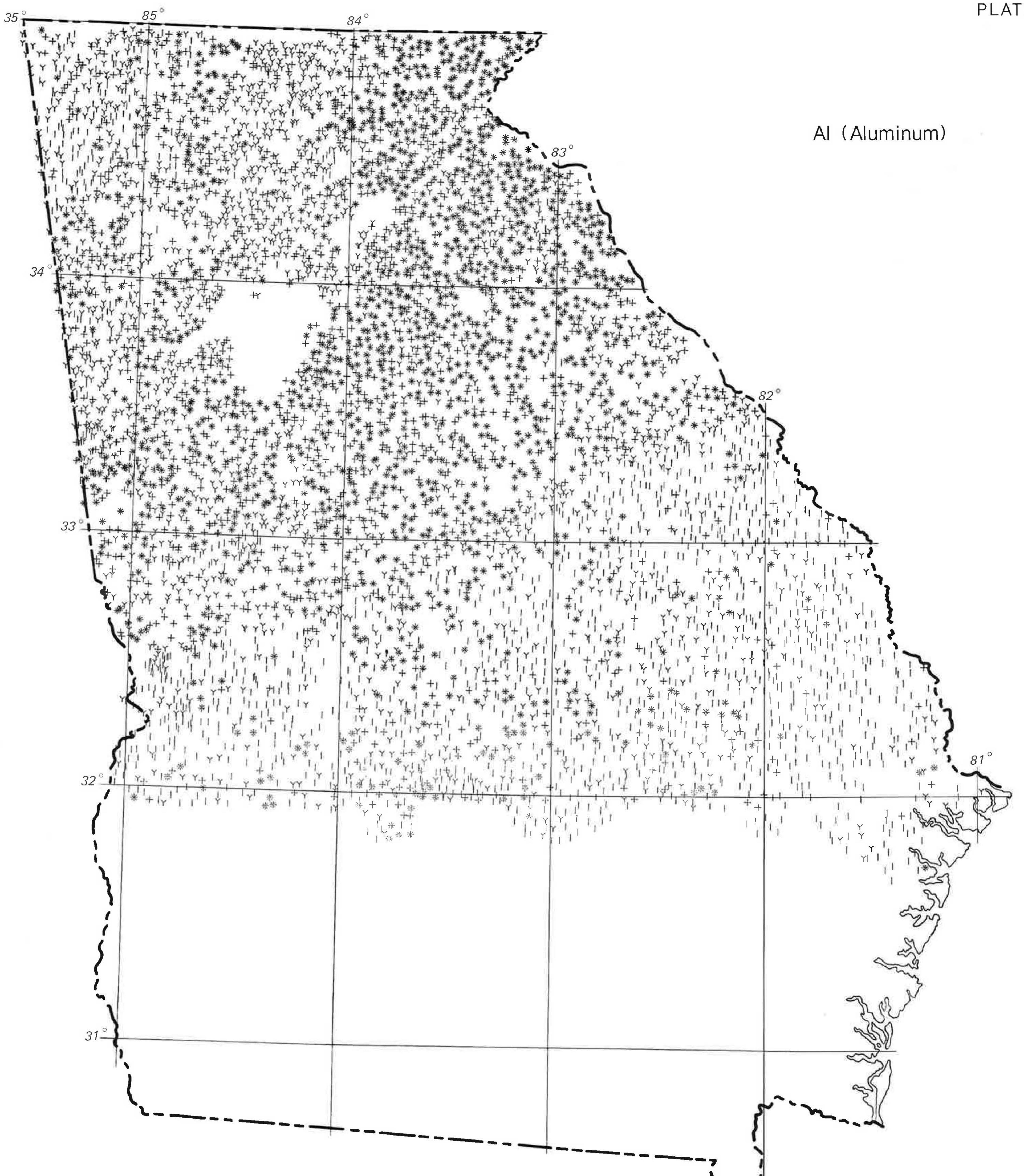
TOTAL NUMBER OF SAMPLES: 2949

Symbol	PPM	Percent of data
*		25.0
+		25.0
Y		25.0
I		25.0

0 10 25 50 MILES

1:1,785,000

Al (Aluminum)



TOTAL NUMBER OF SAMPLES: 5713

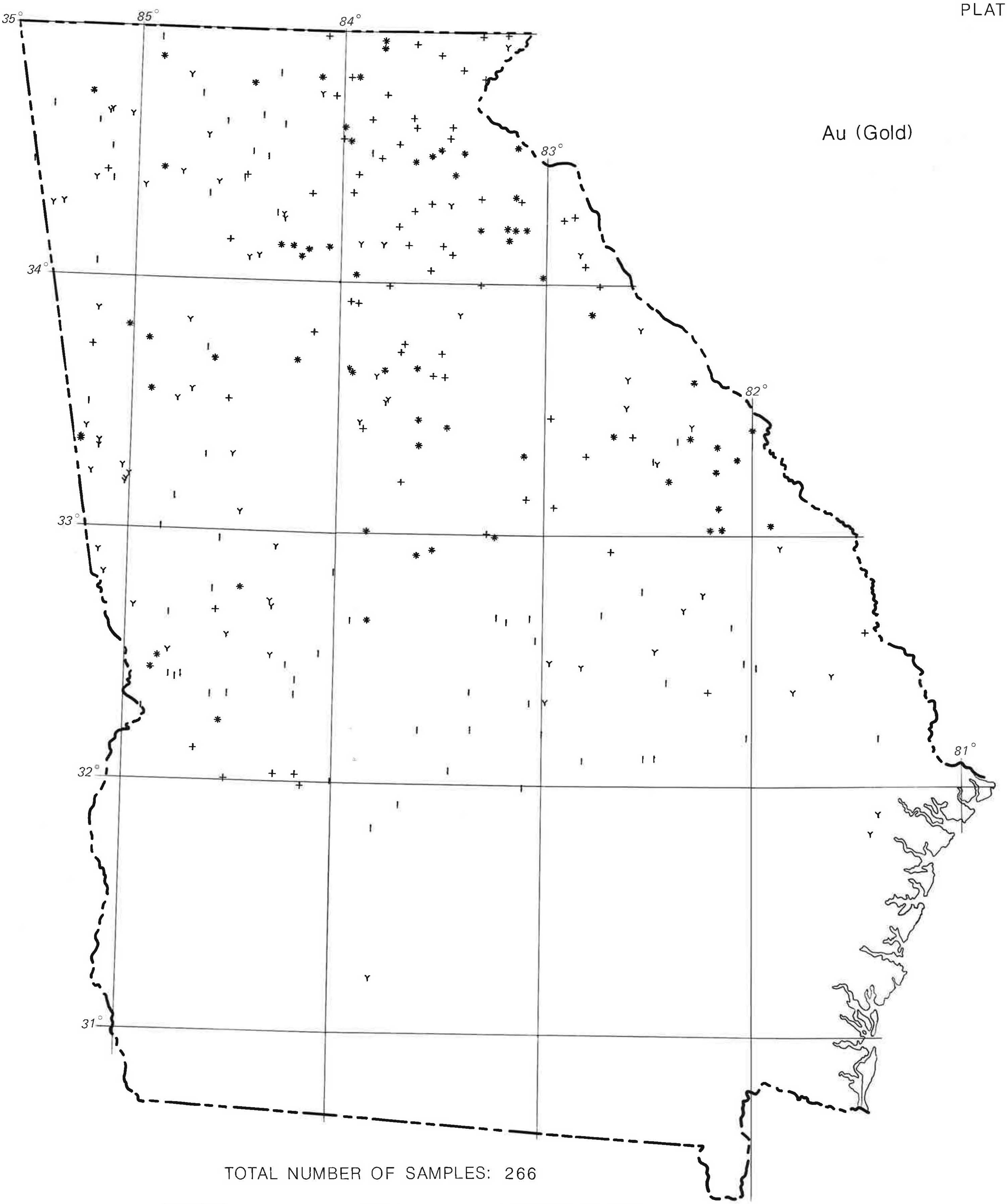
Symbol	PCT	Percent of data
*	34.64 – 4.49	25.0
+	4.49 – 2.80	25.0
Y	2.80 – 1.36	25.0
ı	≤ 1.36	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 4

Au (Gold)



TOTAL NUMBER OF SAMPLES: 266

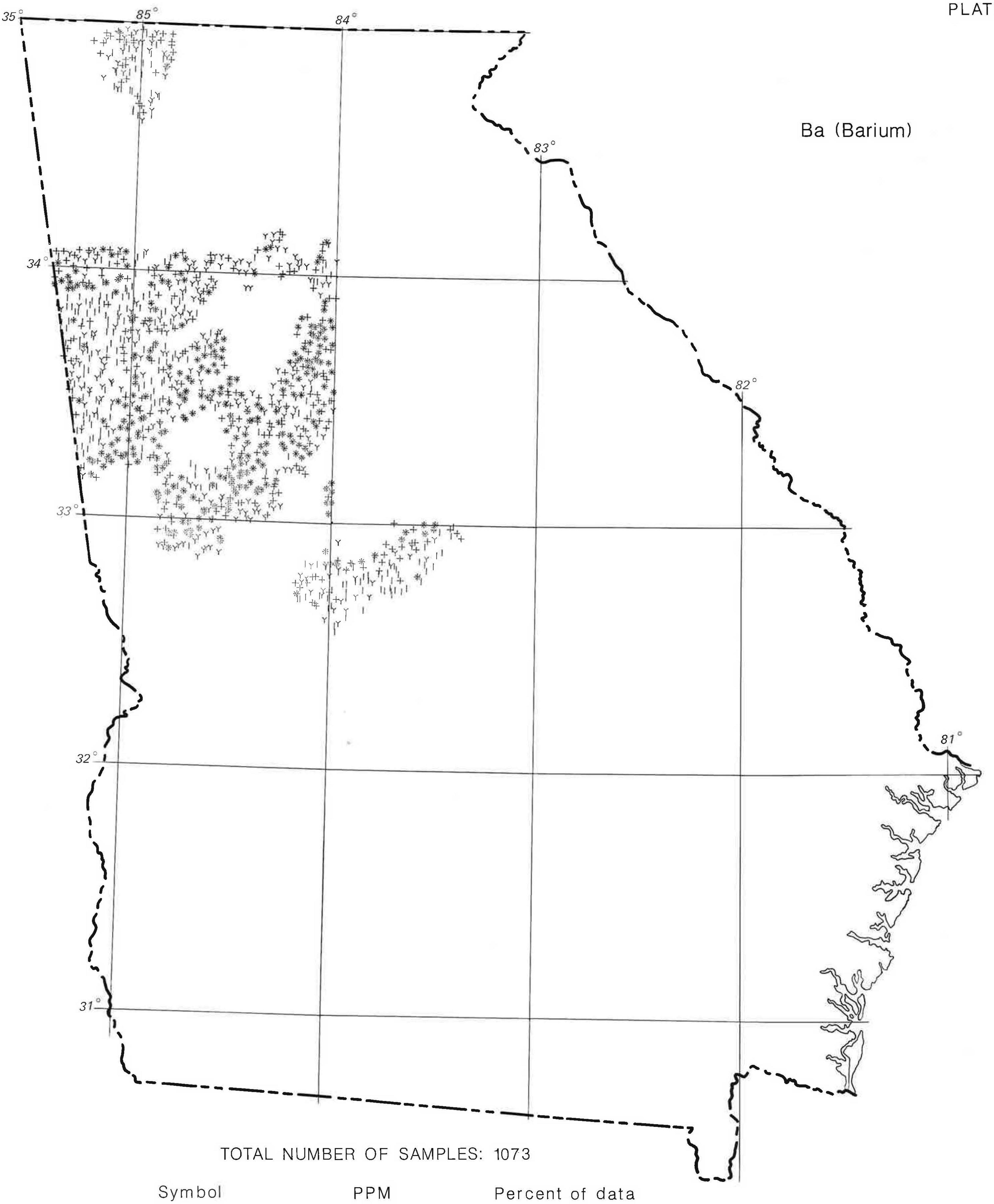
Symbol	PPM	Percent of data
*	18.14 − 0.27	25.0
+	0.27 − 0.08	25.0
Y	0.08 − 0.04	25.0
I	≤ 0.04	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 5

Ba (Barium)

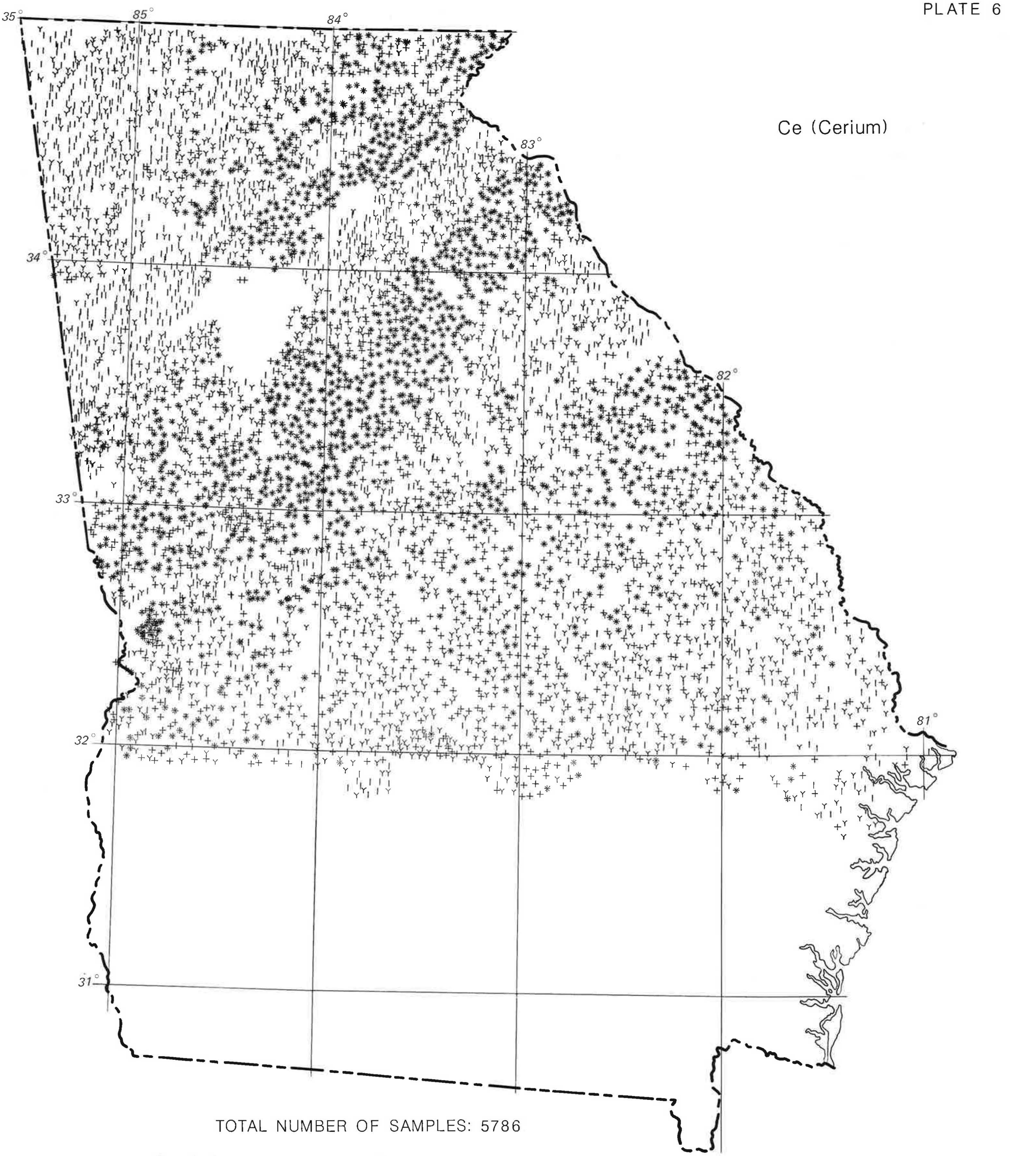


TOTAL NUMBER OF SAMPLES: 1073

Symbol	PPM	Percent of data
*	748 – 78	25.0
+	78 – 27	25.0
Y	27 – 10	25.0
I	≤ 10	25.0

0 10 25 50 MILES

1:1,785,000



TOTAL NUMBER OF SAMPLES: 5786

Symbol	PPM	Percent of data
*	9700 – 279	25.0
+	279 – 104	25.0
Y	104 – 48	25.0
ı	≤ 48	25.0

PLATE 7

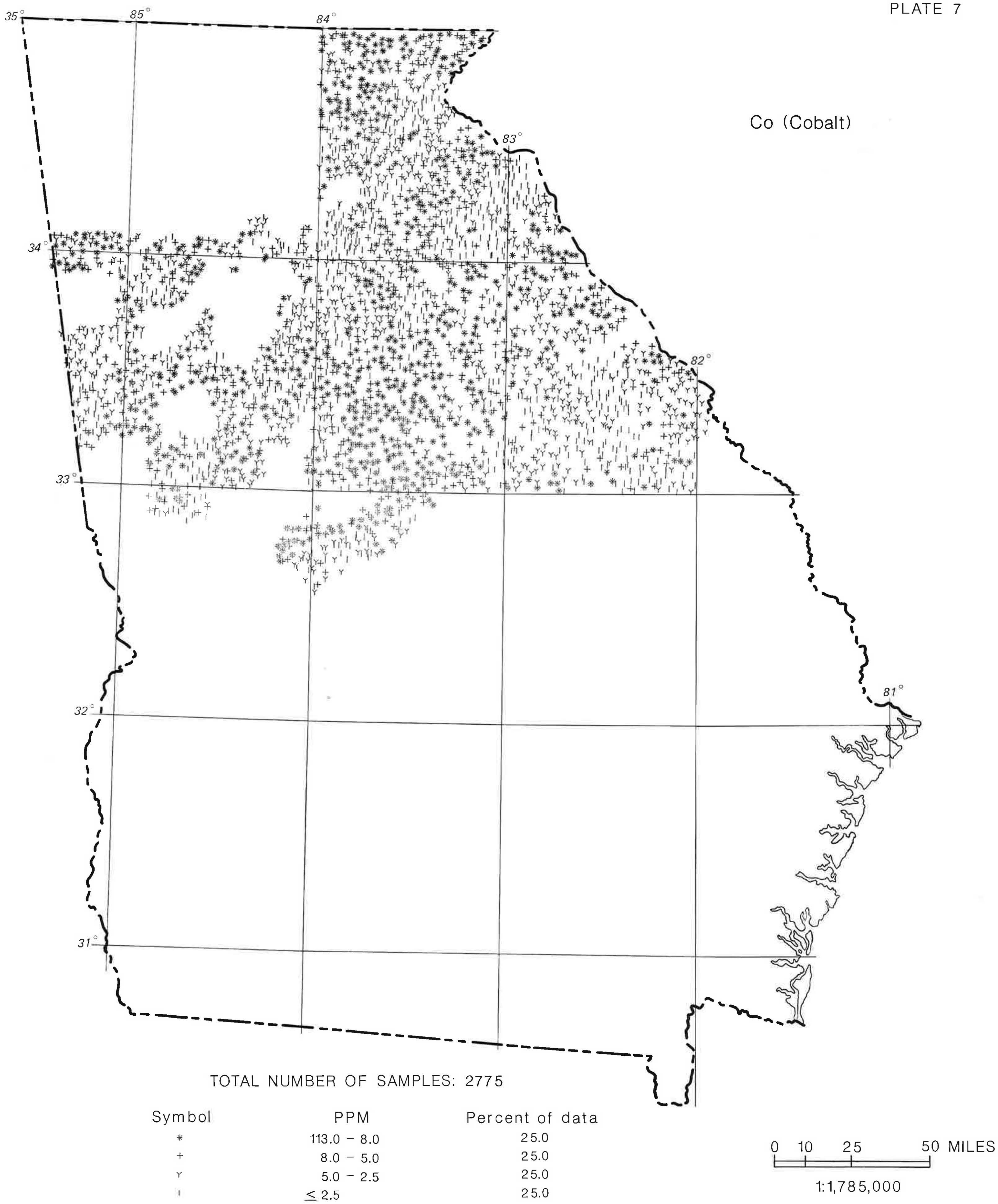
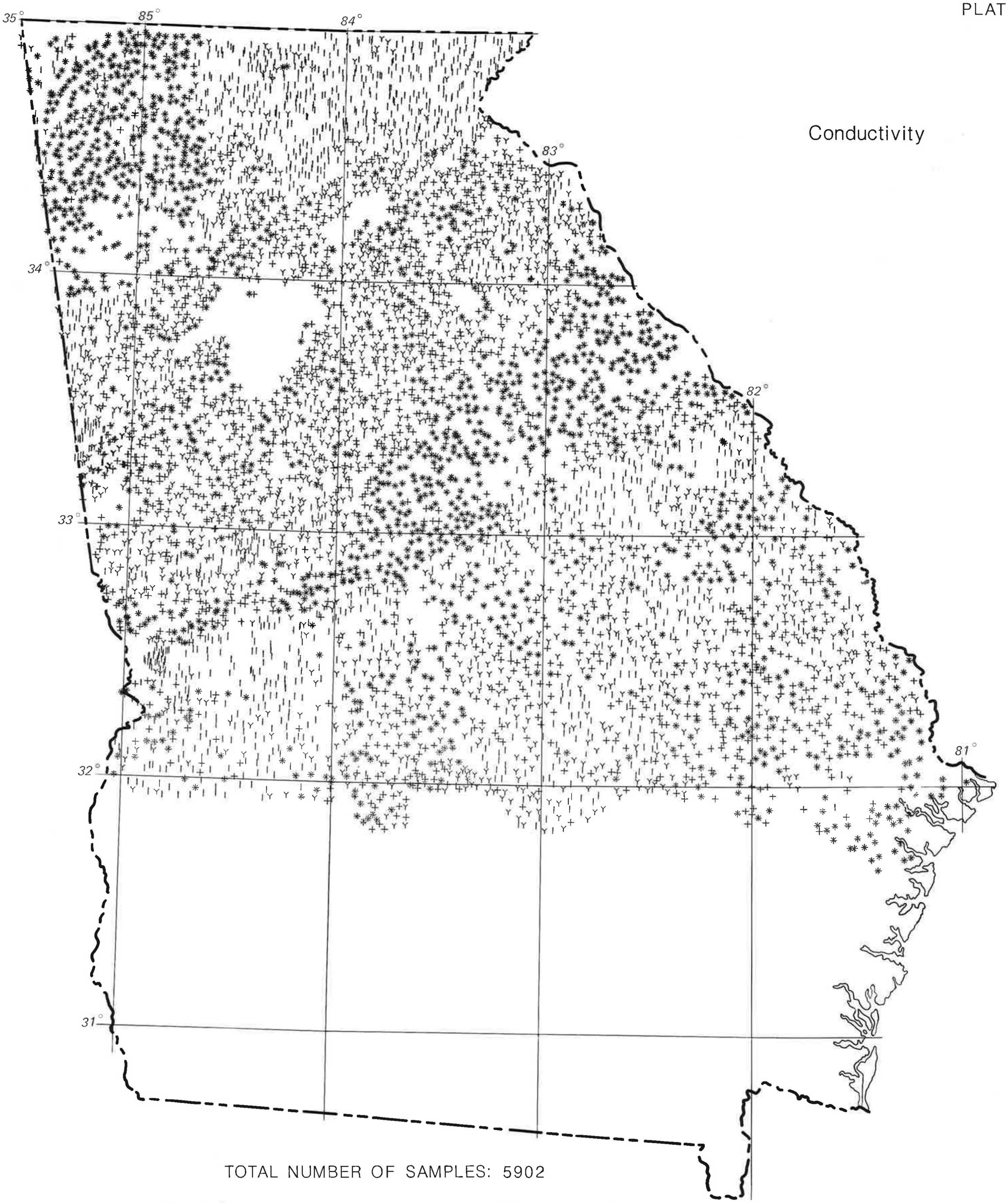

Co (Cobalt)
35°
85°
84°
83°
82°
81°
34°
33°
32°
31°
TOTAL NUMBER OF SAMPLES: 2775
Symbol
PPM
Percent of data
* 113.0 – 8.0 25.0
+ 8.0 – 5.0 25.0
Y 5.0 – 2.5 25.0
I ≤ 2.5 25.0
0 10 25 50 MILES
1:1,785,000

PLATE 8

Conductivity



TOTAL NUMBER OF SAMPLES: 5902

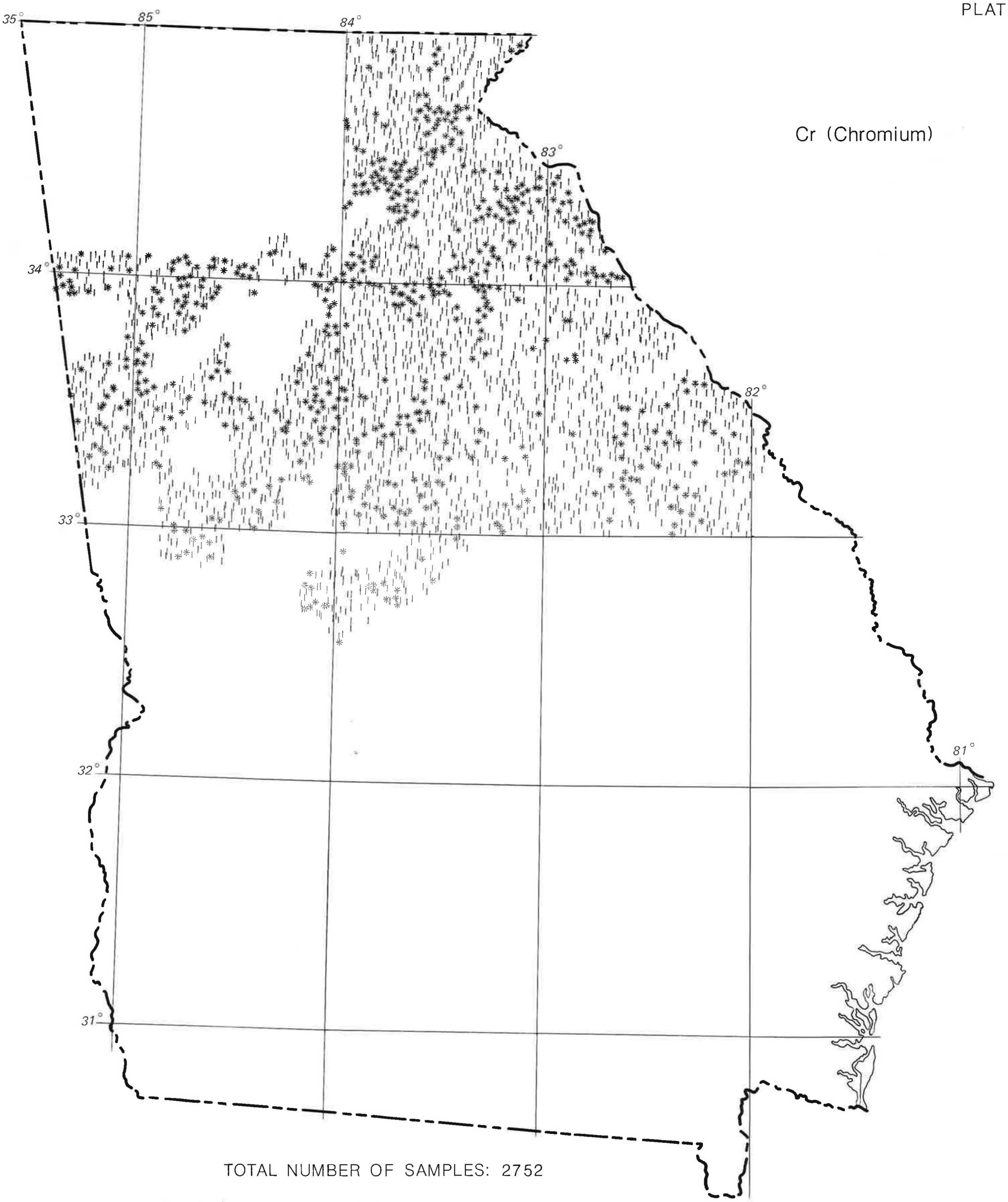
Symbol	μ mho/cm	Percent of data
*	32,000 – 61	25.0
+	61 – 42	25.0
Y	42 – 30	25.0
ı	≤ 30	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 9

Cr (Chromium)



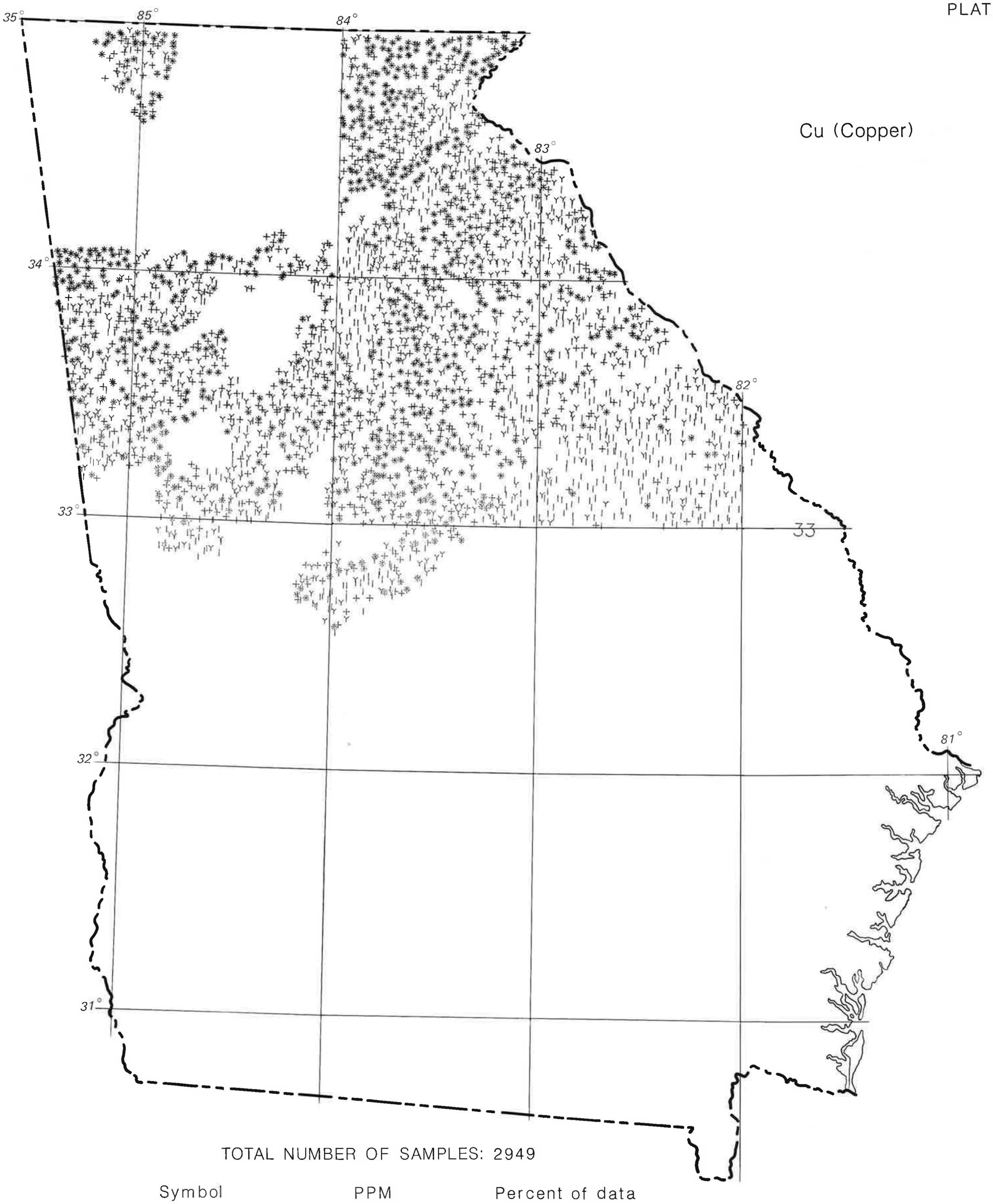
TOTAL NUMBER OF SAMPLES: 2752

Symbol	PPM	Percent of data
*	214 – 5	77.0
ı	≤ 5	23.0

0 10 25 50 MILES

1:1,785,000

PLATE 10



TOTAL NUMBER OF SAMPLES: 2949

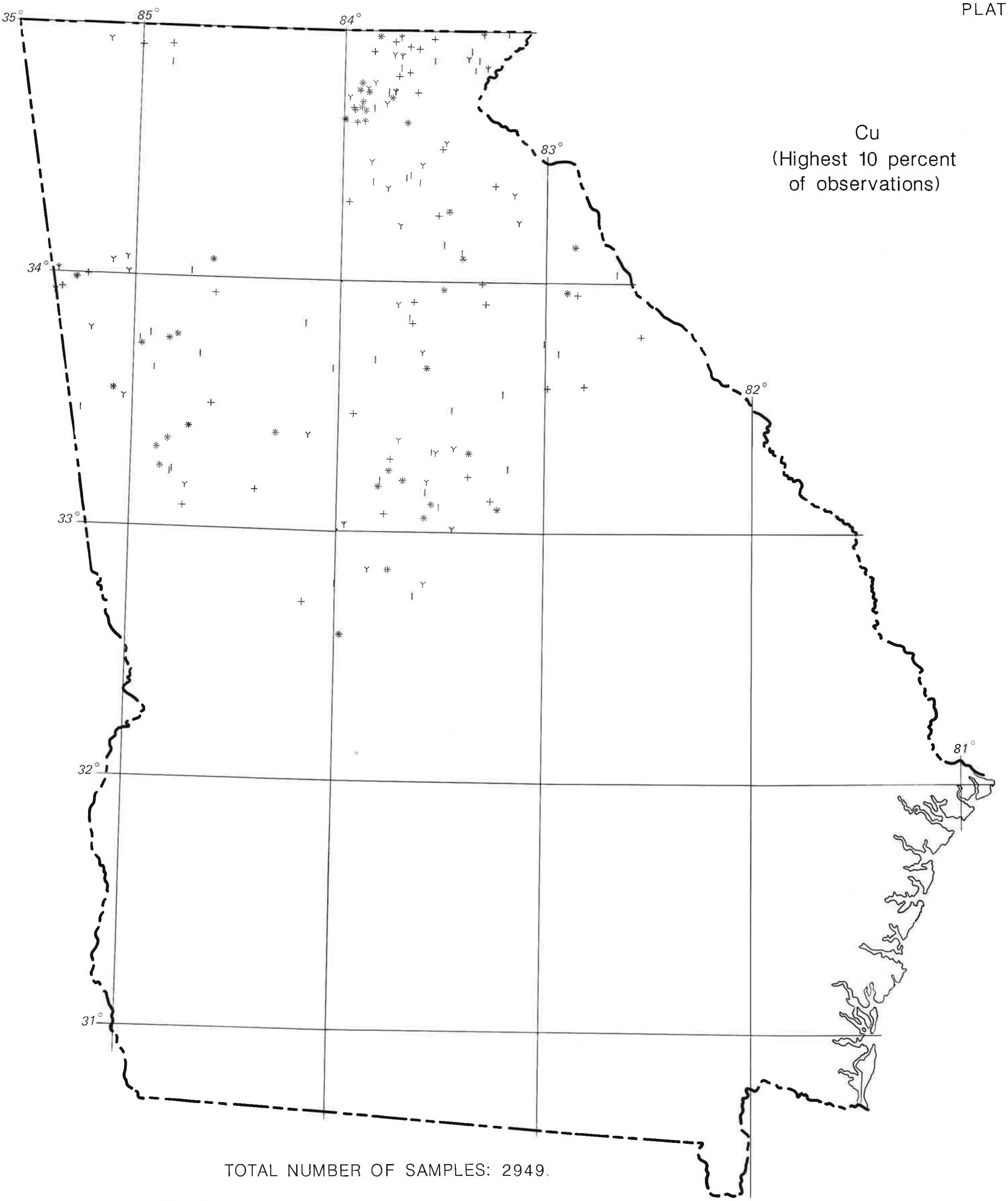
Symbol	PPM	Percent of data
*	155 – 8	25.0
+	8 – 5	25.0
Y	5 – 3	25.0
ı	≤ 3	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 11

Cu
(Highest 10 percent
of observations)



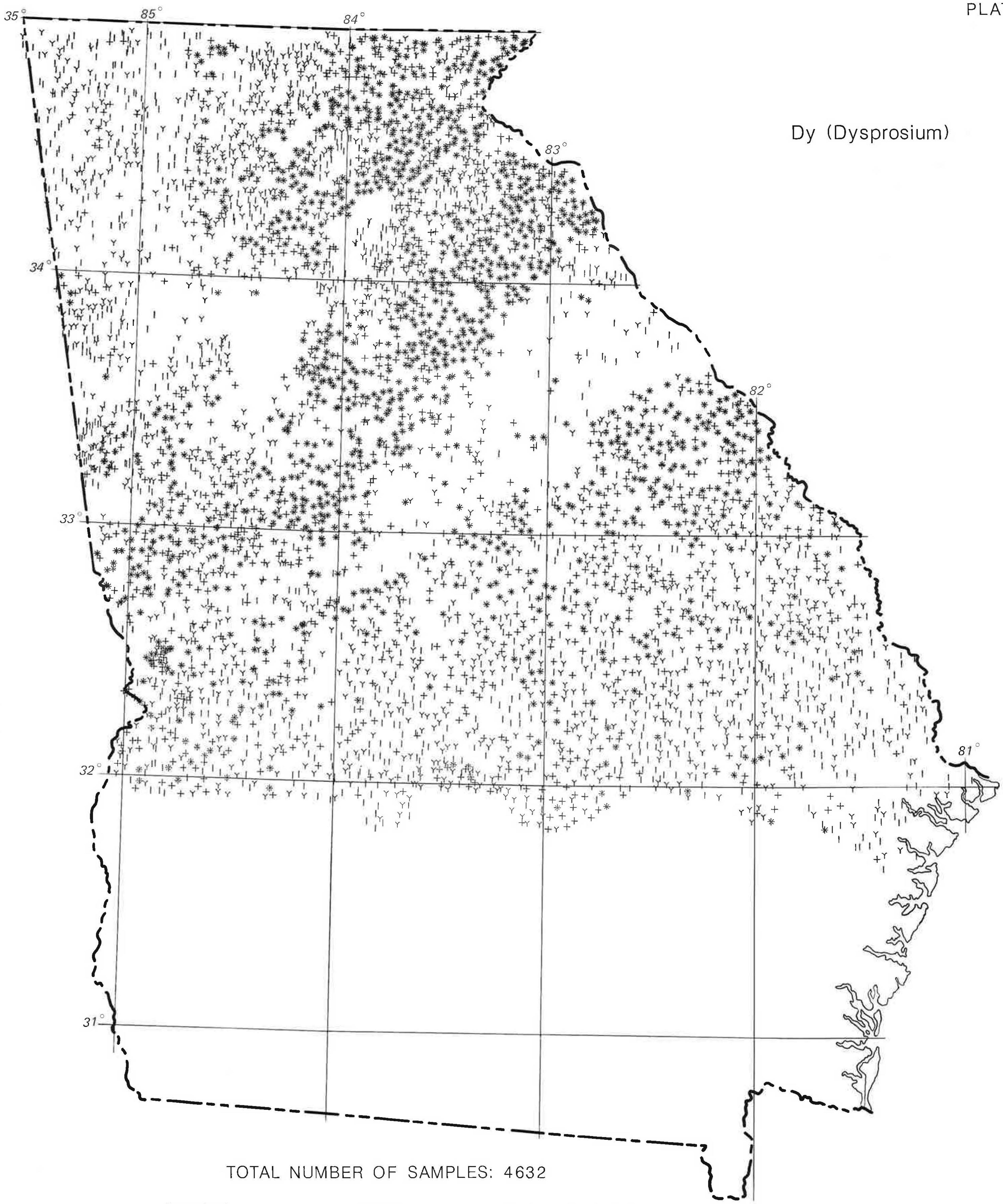
TOTAL NUMBER OF SAMPLES: 2949.

Symbol	PPM	Percent of data
*	155 – 26	2.5
+	26 – 20	2.5
Y	20 – 18	2.5
I	18 16	2.5

0 10 25 50 MILES

1:1,785,000

PLATE 12



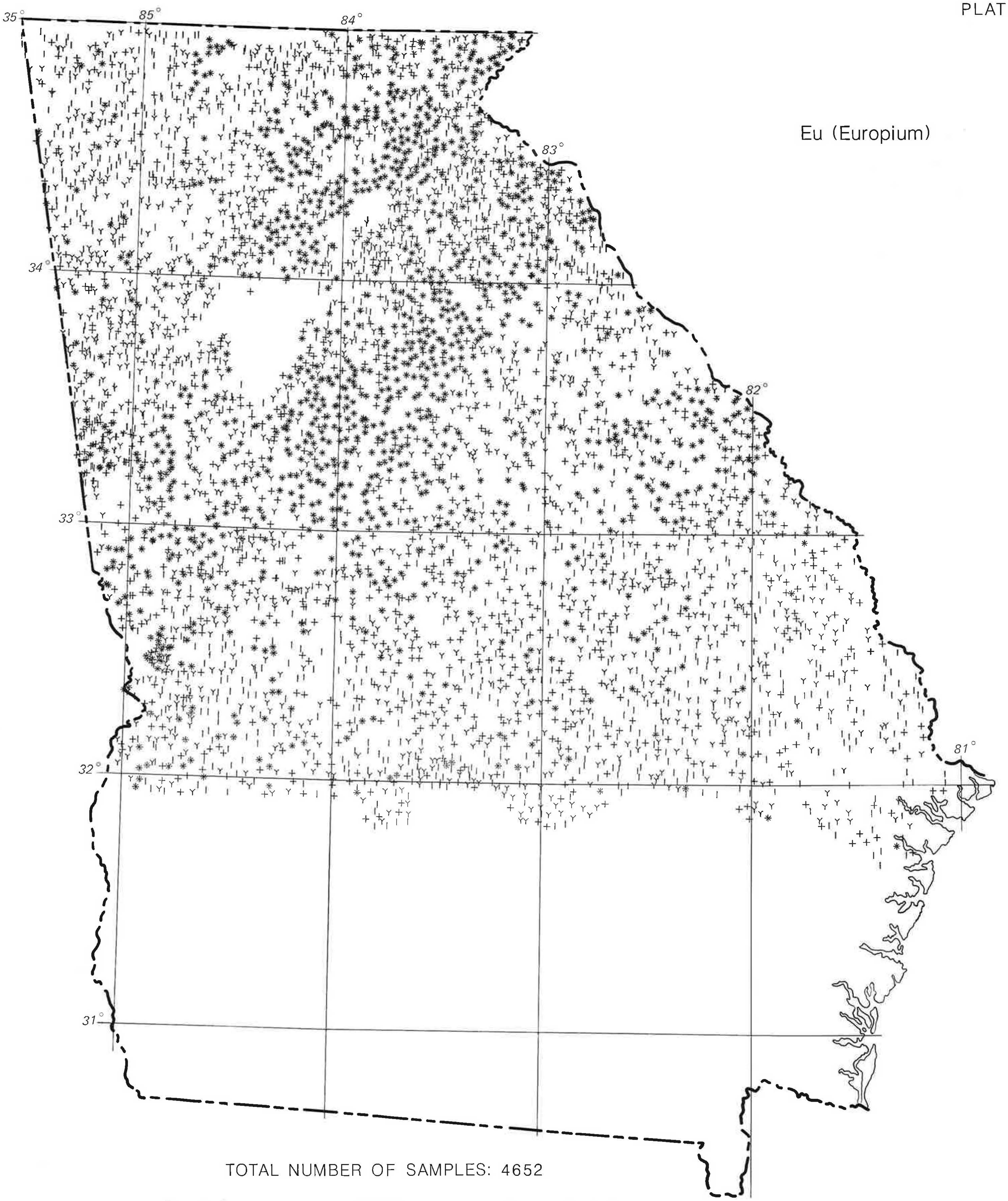
TOTAL NUMBER OF SAMPLES: 4632

Symbol	PPM	Percent of data
*	441 – 18	25.0
+	18 – 8	25.0
Y	8 – 4	25.0
ı	≤4	25.0

0 10 25 50 MILES

1:1,785,000

Eu (Europium)



TOTAL NUMBER OF SAMPLES: 4652

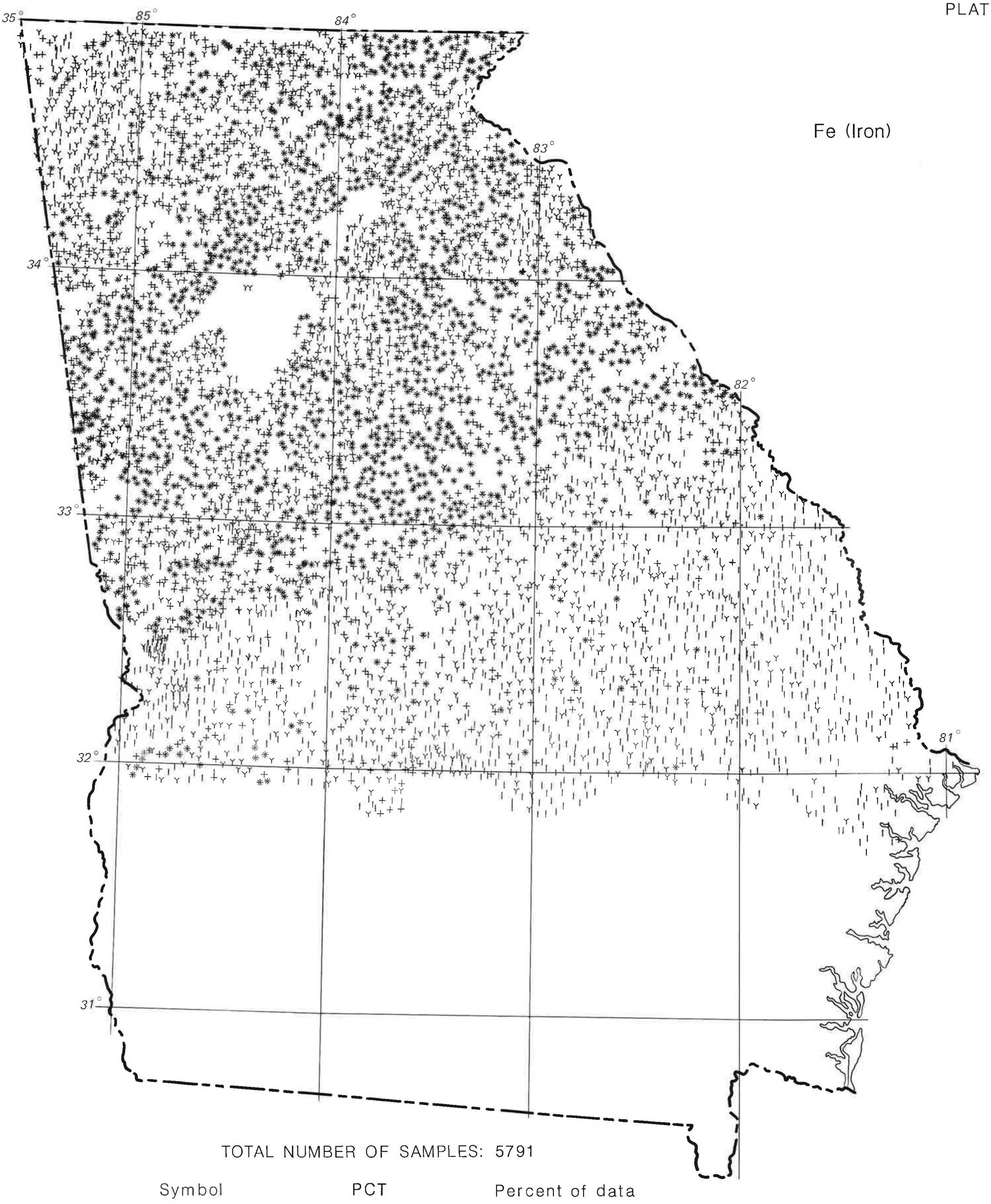
Symbol	PPM	Percent of data
*	74.9 – 3.1	25.0
+	3.1 – 0.9	25.0
Y	0.9 – 0.5	25.0
I	≤0.5	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 14

Fe (Iron)



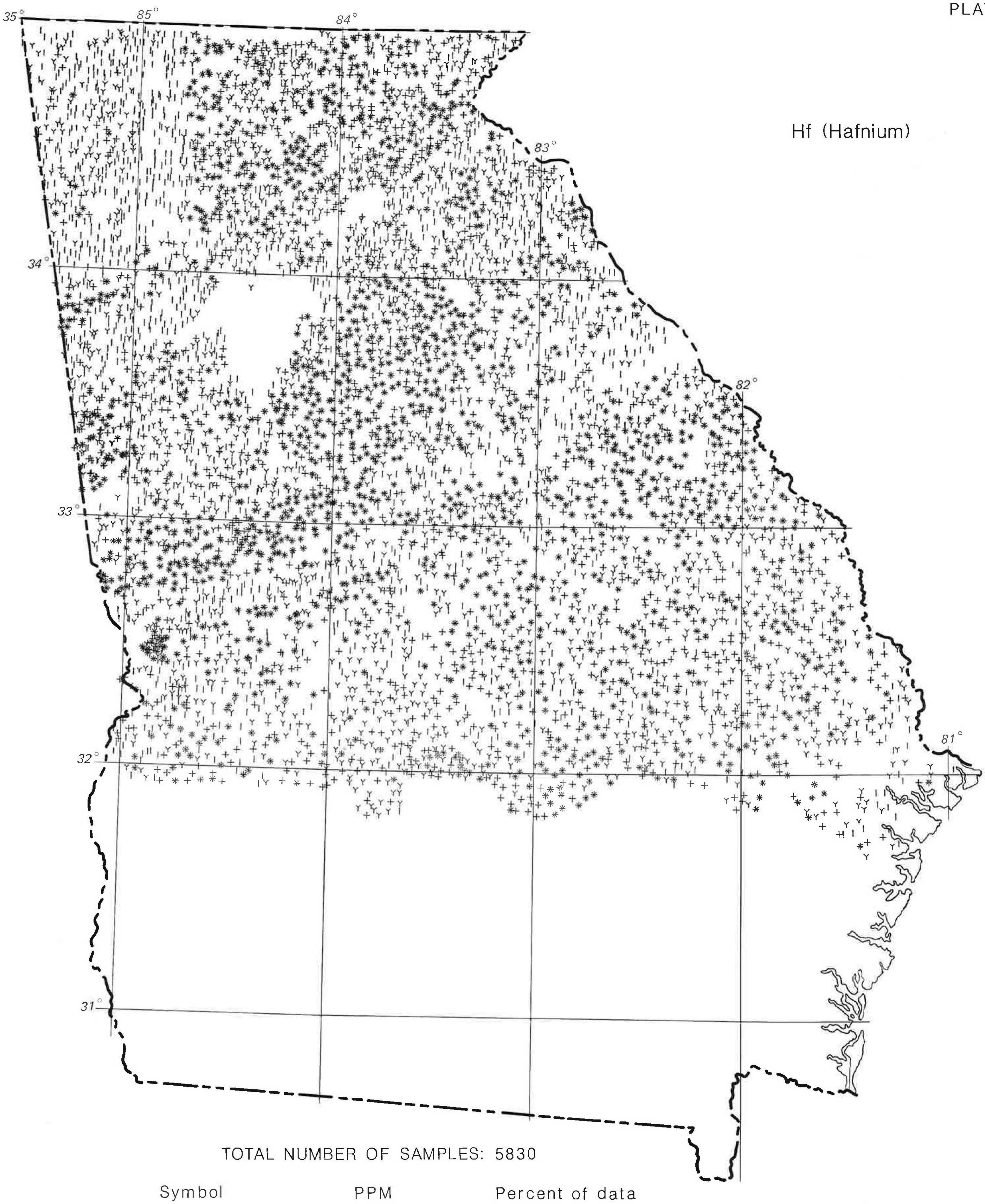
TOTAL NUMBER OF SAMPLES: 5791

Symbol	PCT	Percent of data
*	45.92 – 3.50	25.0
+	3.50 – 2.12	25.0
Y	2.12 – 1.14	25.0
I	≤ 1.14	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 15

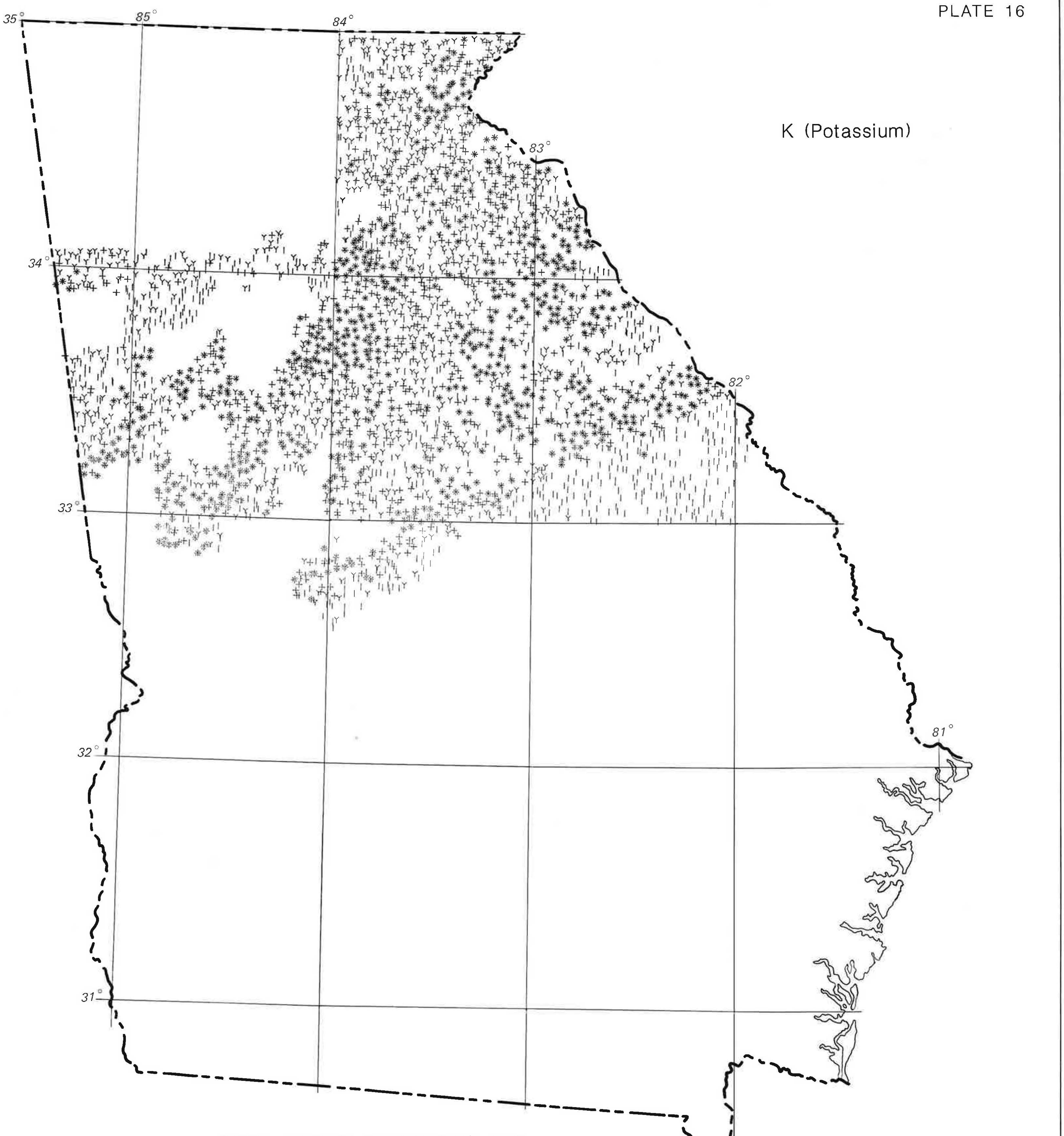


TOTAL NUMBER OF SAMPLES: 5830

Symbol	PPM	Percent of data
*	4806 - 74	25.0
+	74 - 40	25.0
Y	40 - 21	25.0
I	≤21	25.0

0 10 25 50 MILES

1:1,785,000



TOTAL NUMBER OF SAMPLES: 2756

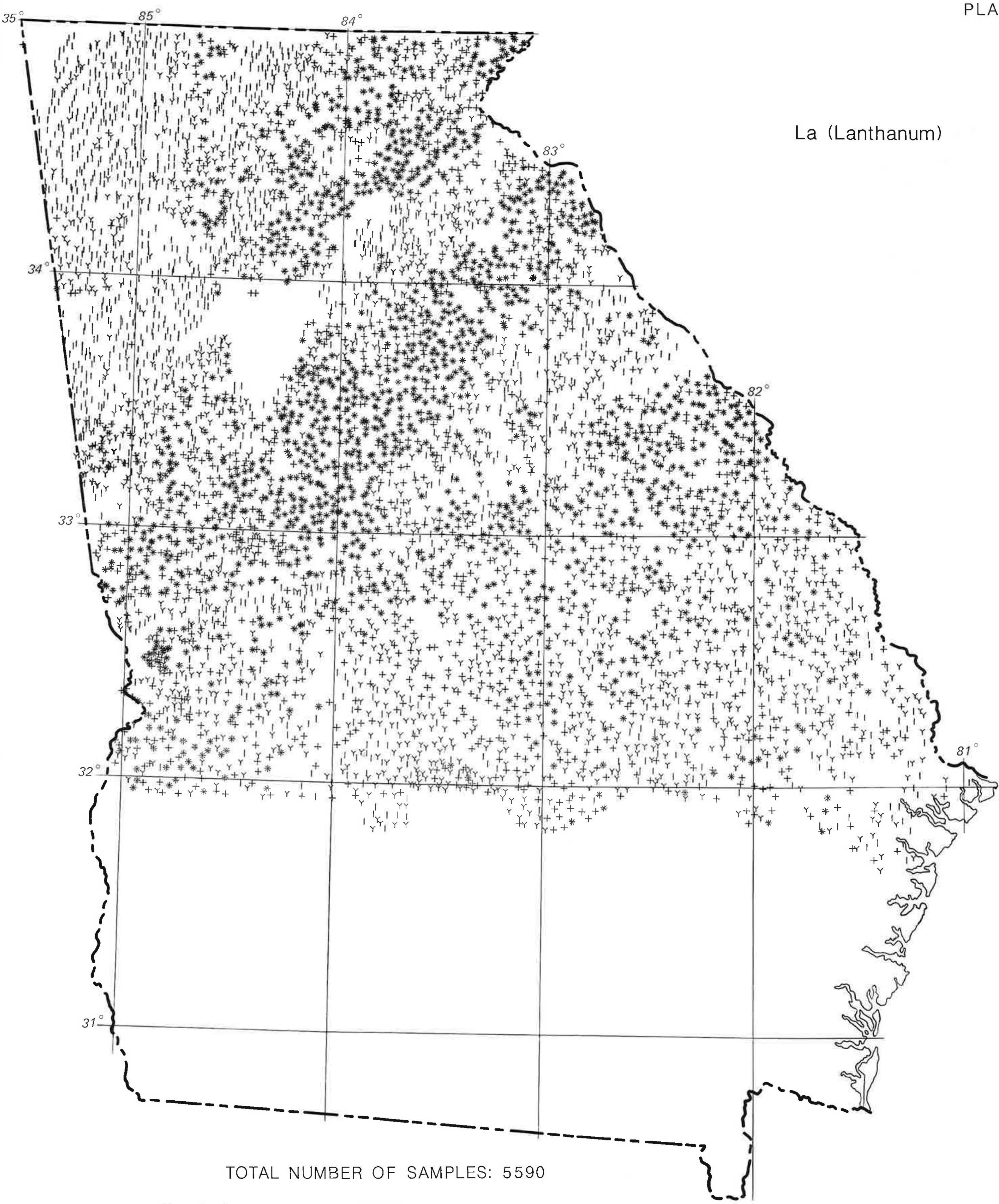
Symbol	PPM	Percent of data
*	16.0 – 1.6	25.0
+	1.6 – 1.0	25.0
Y	1.0 – 0.5	25.0
I	≤0.5	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 17

La (Lanthanum)



TOTAL NUMBER OF SAMPLES: 5590

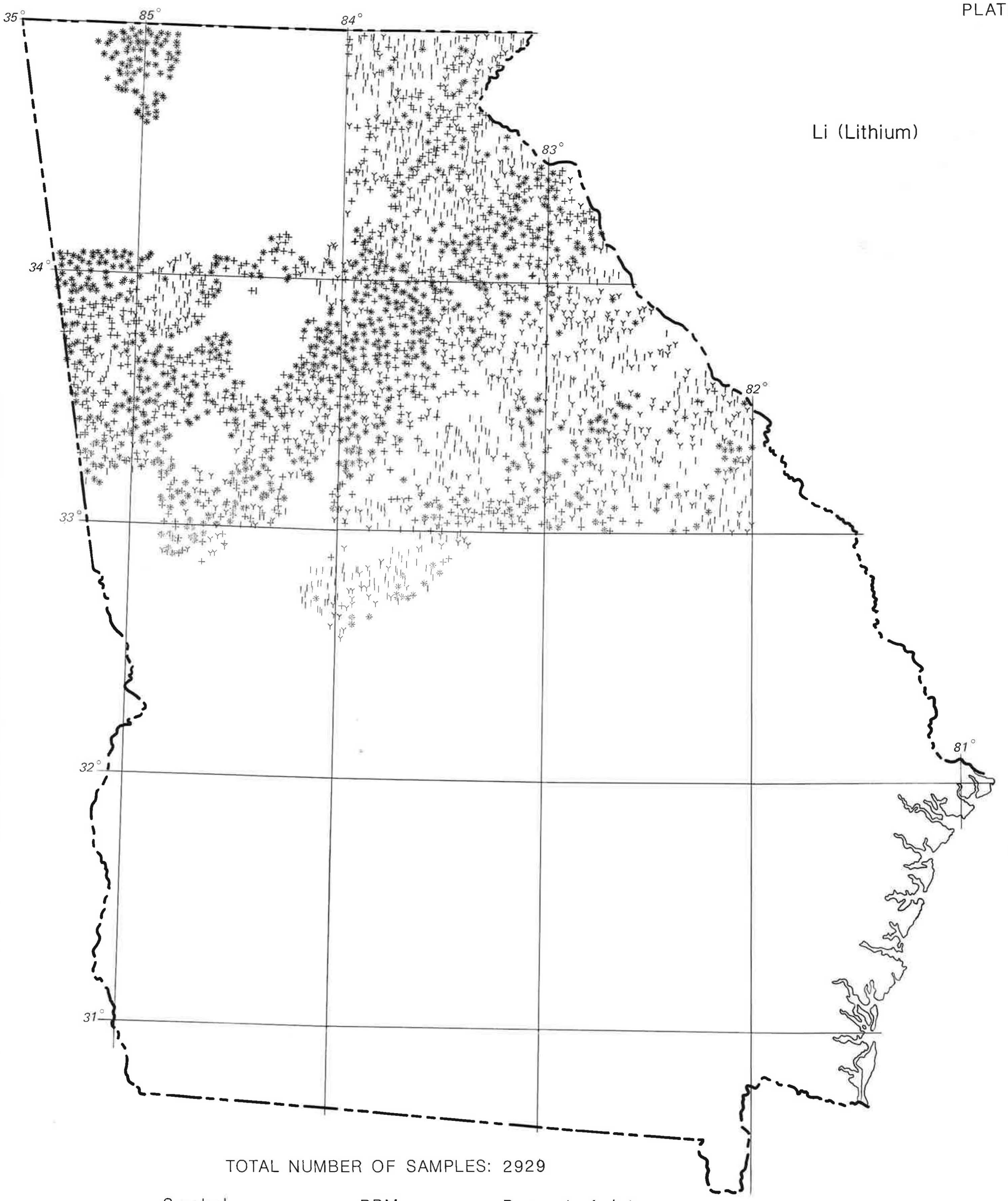
Symbol	PPM	Percent of data
*	5306 – 158	25.0
+	158 – 56	25.0
Y	56 – 26	25.0
I	≤26	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 18

Li (Lithium)

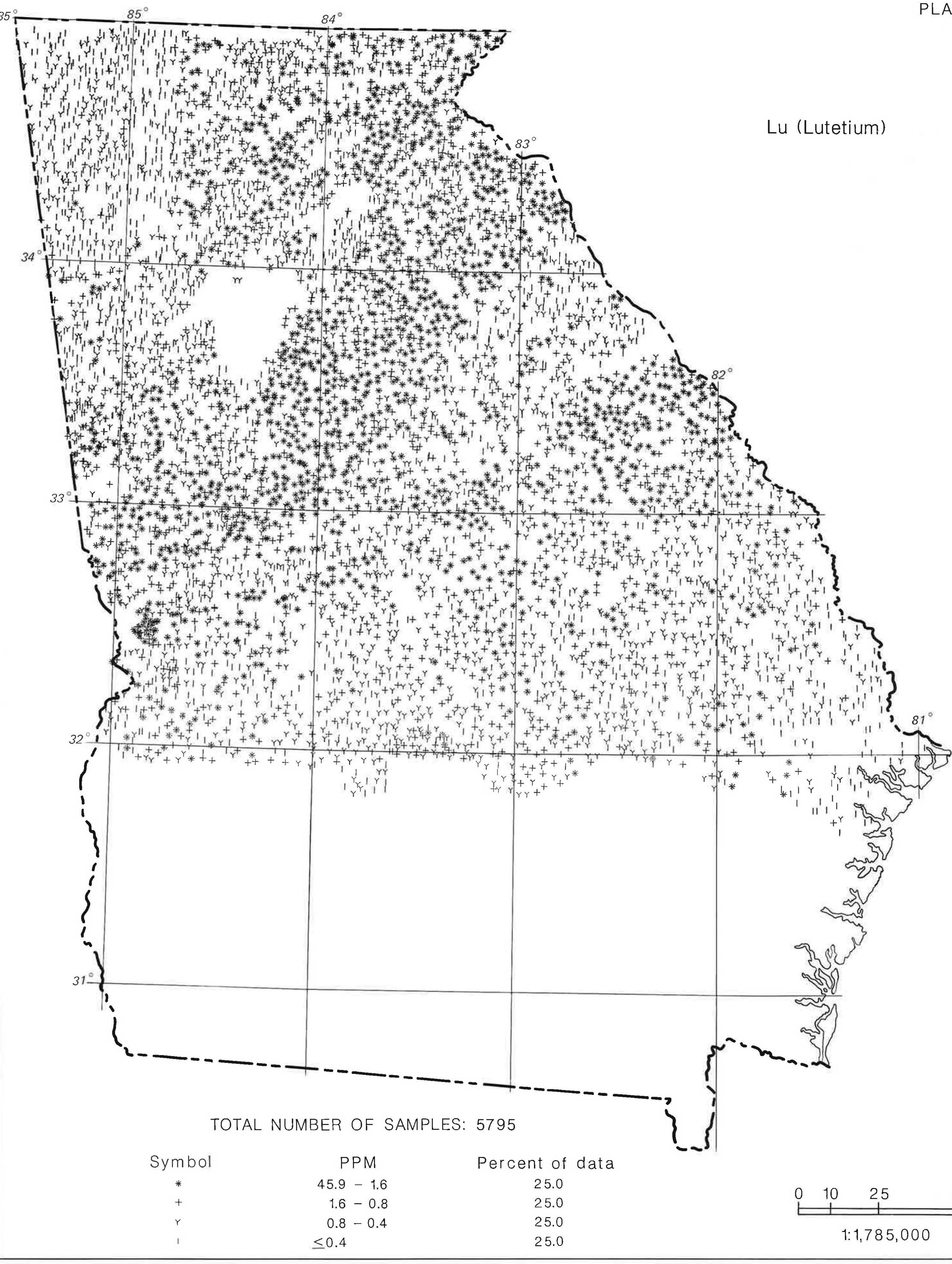


TOTAL NUMBER OF SAMPLES: 2929

Symbol	PPM	Percent of data
*	150.0 – 10.0	25.0
+	10.0 – 5.0	25.0
Y	5.0 – 2.6	25.0
ı	≤2.6	25.0

0 10 25 50 MILES

1:1,785,000



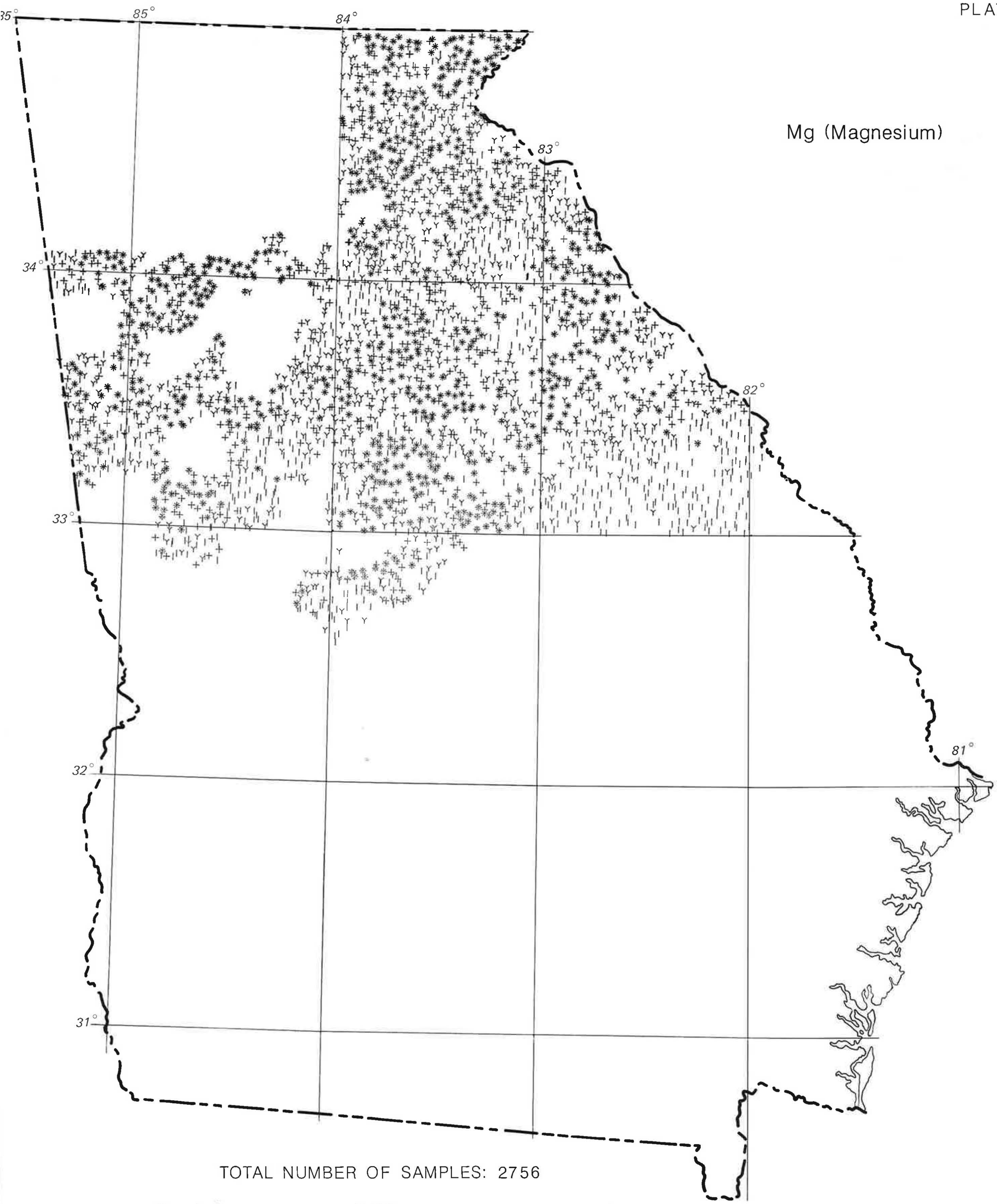
TOTAL NUMBER OF SAMPLES: 5795

Symbol	PPM	Percent of data
*	45.9 – 1.6	25.0
+	1.6 – 0.8	25.0
Y	0.8 – 0.4	25.0
I	≤0.4	25.0

0 10 25 50 MILES

1:1,785,000

Mg (Magnesium)



TOTAL NUMBER OF SAMPLES: 2756

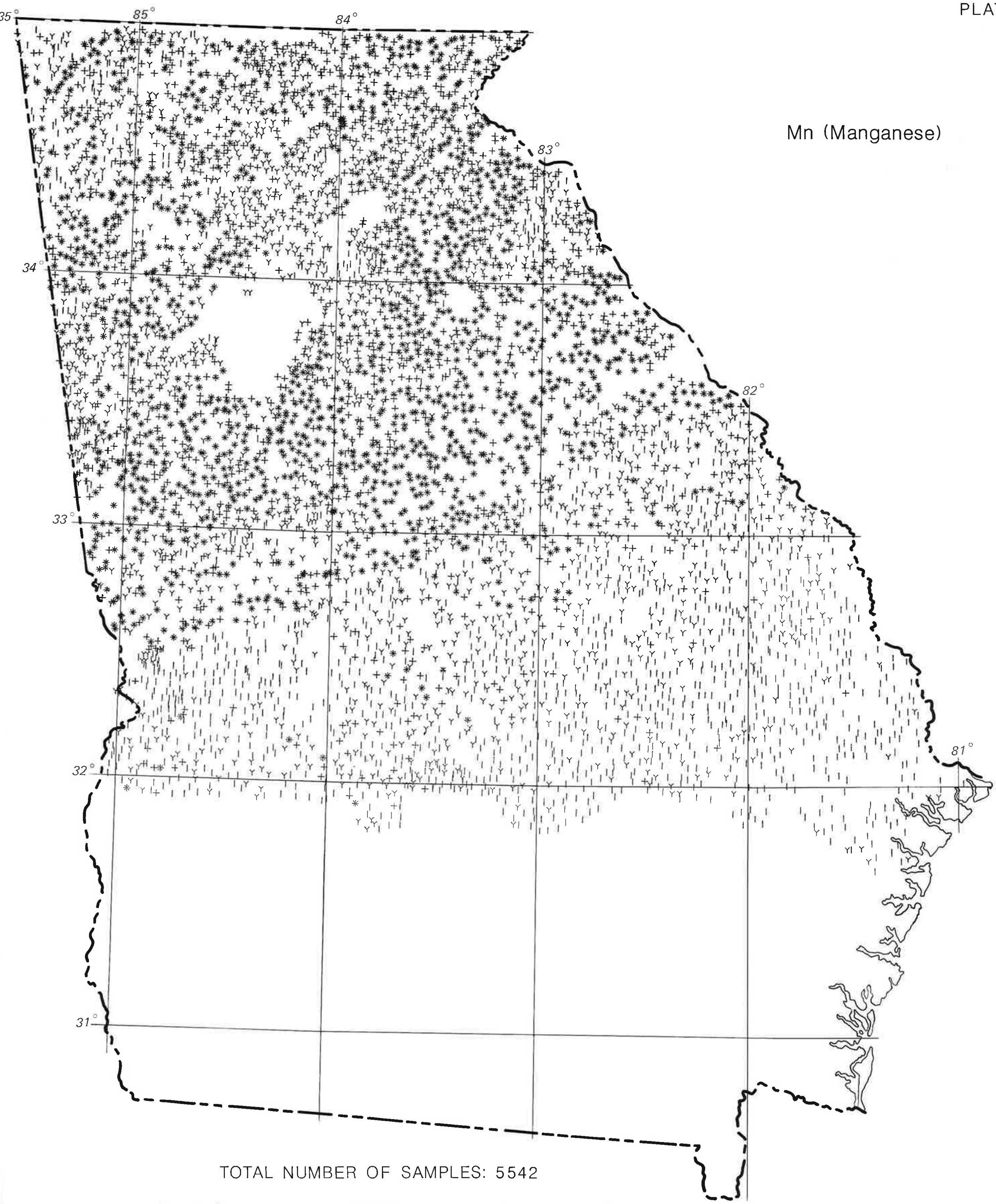
Symbol	PCT	Percent of data
*	2.60 – 0.23	25.0
+	0.23 – 0.16	25.0
Y	0.16 – 0.10	25.0
ı	≤0.10	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 21

Mn (Manganese)



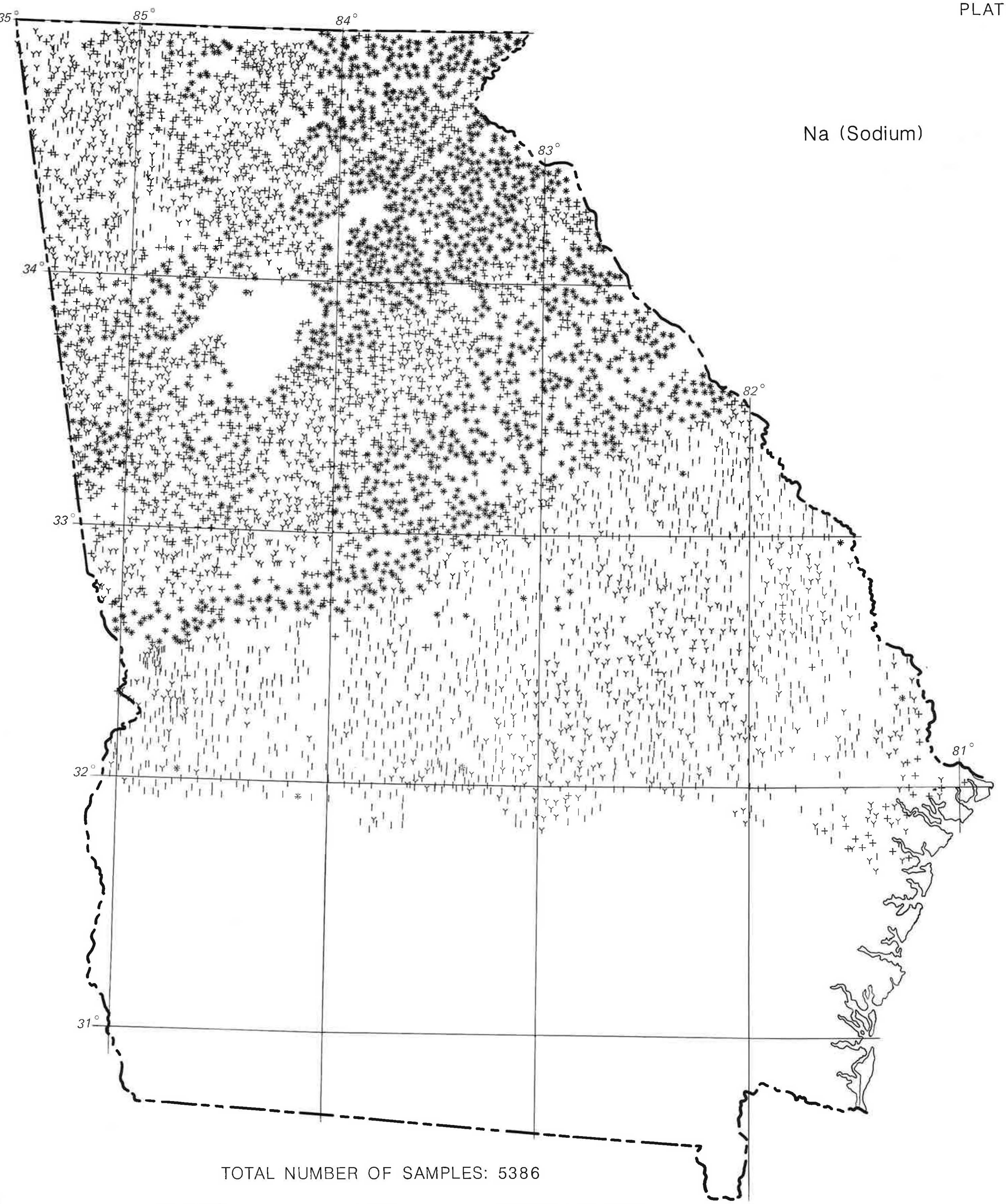
TOTAL NUMBER OF SAMPLES: 5542

Symbol	PPM	Percent of data
*	20,300 – 960	25.0
+	960 – 490	25.0
Y	490 – 200	25.0
ı	≤200	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 22



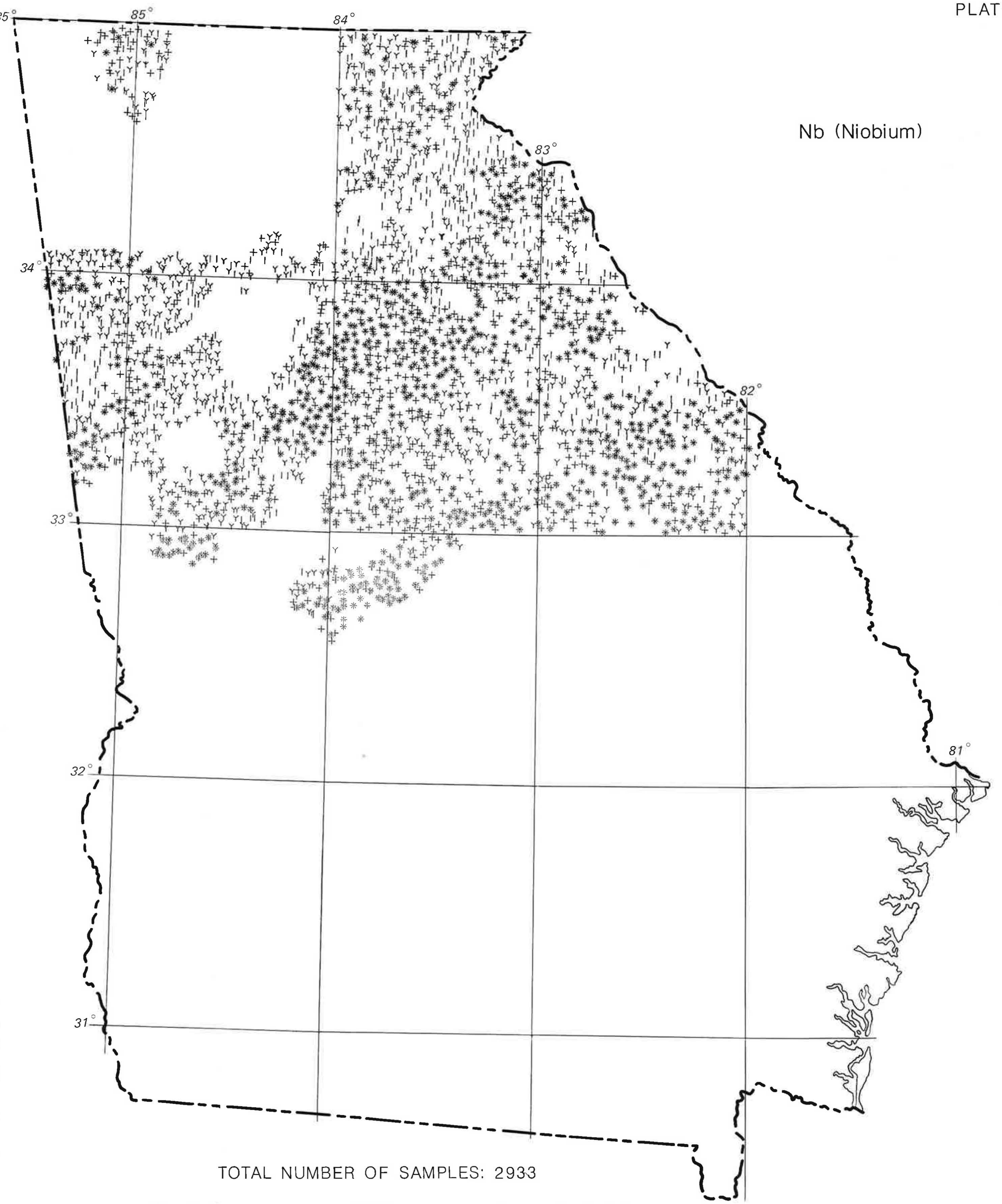
TOTAL NUMBER OF SAMPLES: 5386

Symbol	PPM	Percent of data
*	9.68 – 0.51	25.0
+	0.51 – 0.14	25.0
Y	0.14 – 0.03	25.0
I	≤0.03	25.0

0 10 25 50 MILES

1:1,785,000

Nb (Niobium)



TOTAL NUMBER OF SAMPLES: 2933

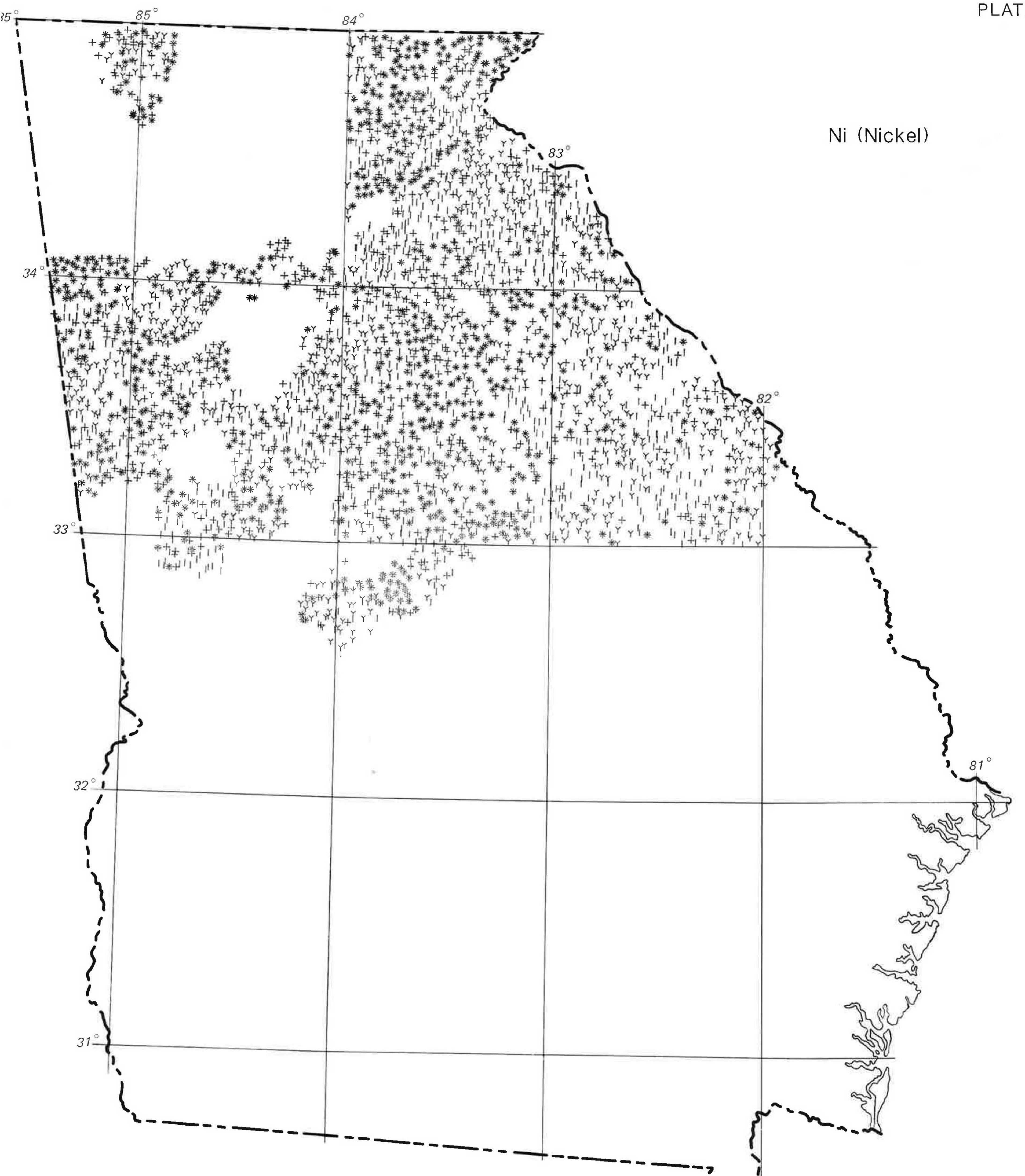
Symbol	PPM	Percent of data
*	300 – 30	25.0
+	30 – 15	25.0
Y	15 – 10	25.0
ı	≤10	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 24

Ni (Nickel)



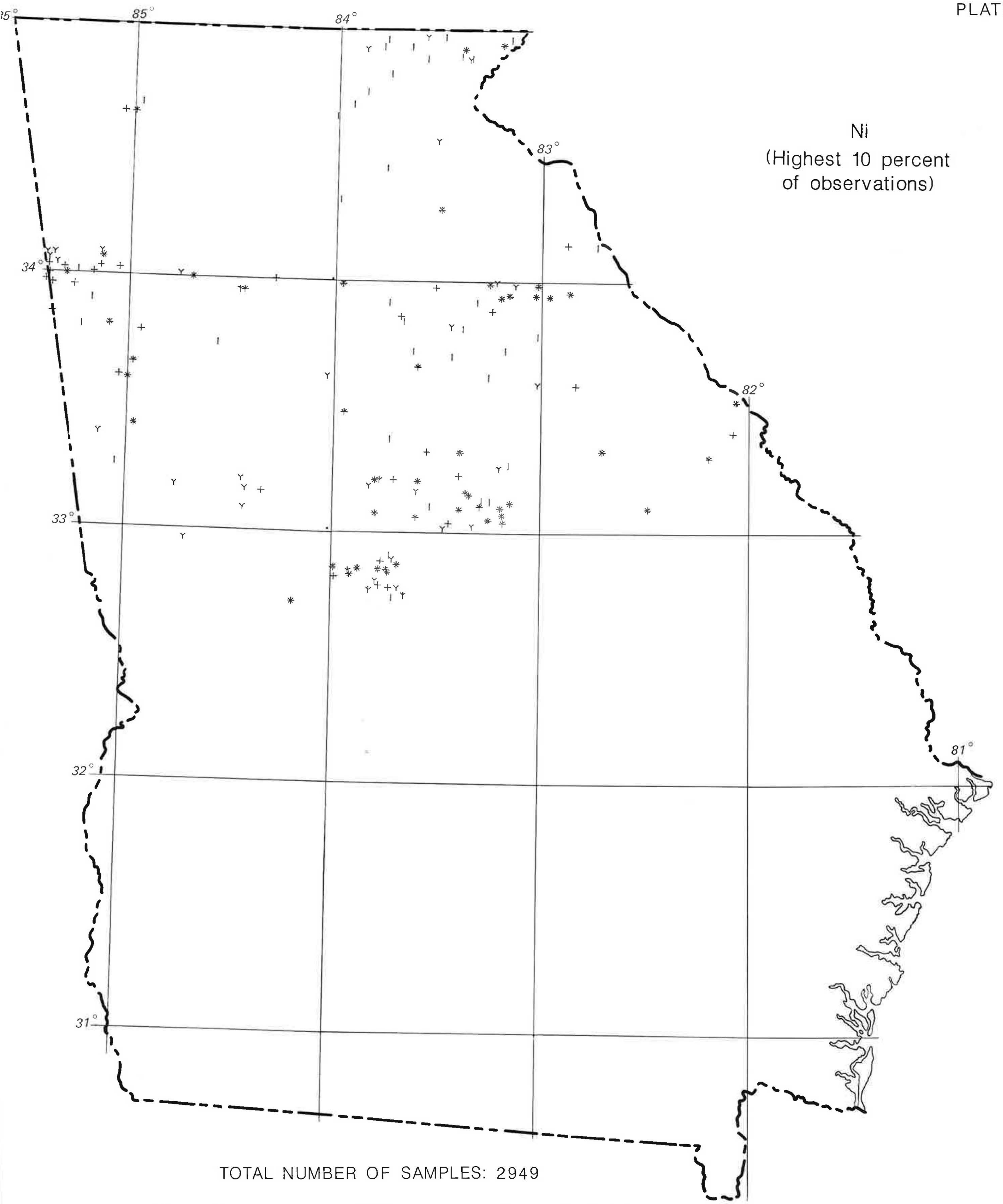
TOTAL NUMBER OF SAMPLES: 2949

Symbol	PPM	Percent of data
*	80 – 8	25.0
+	8 – 5	25.0
Y	5 – 3	25.0
ı	≤3	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 25



Ni
(Highest 10 percent
of observations)

TOTAL NUMBER OF SAMPLES: 2949

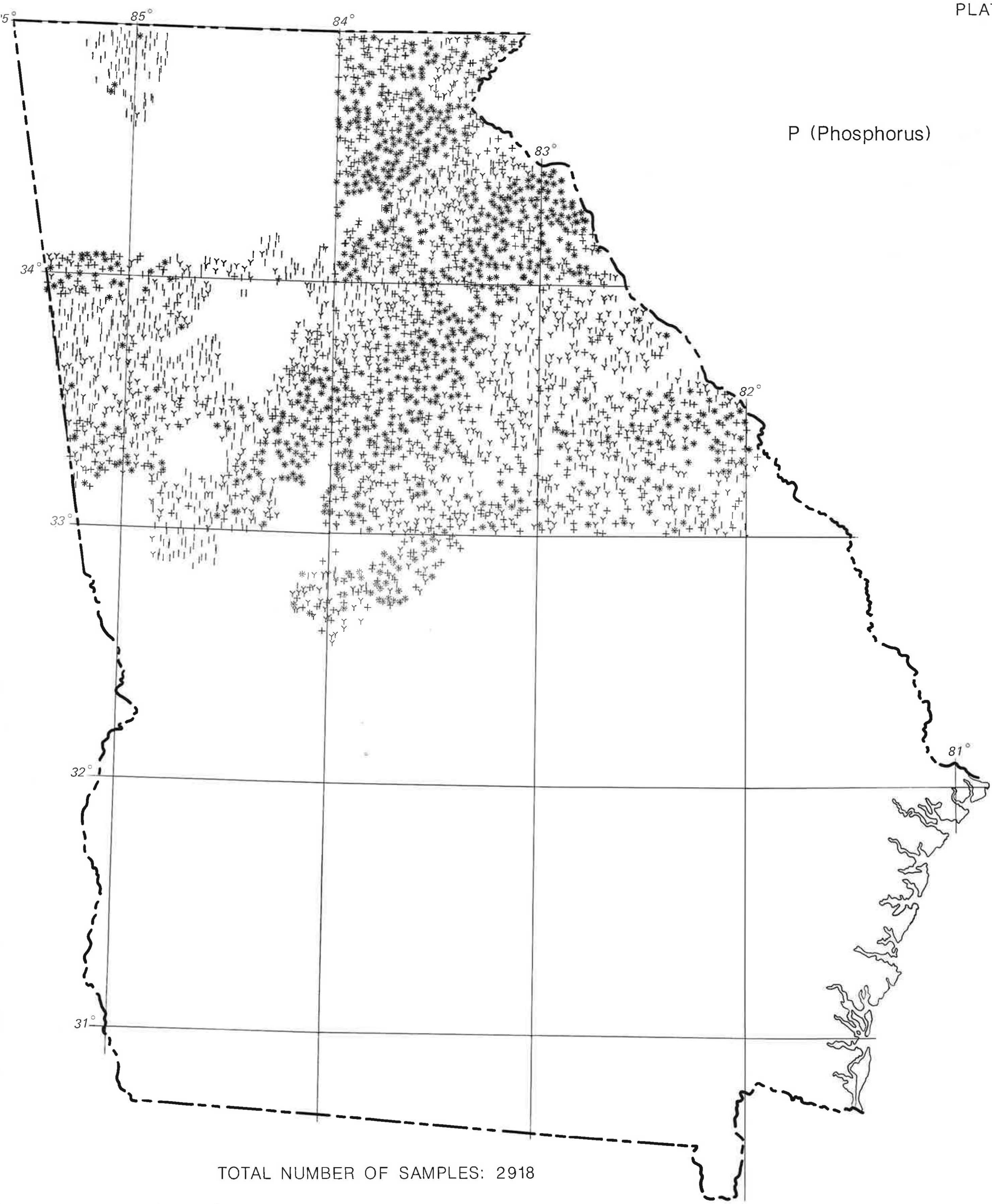
Symbol	PPM	Percent of data
*	80 – 25	2.5
+	25 – 20	2.5
Y	20 – 18	2.5
I	18 – 15	2.5

0 10 25 50 MILES

1:1,785,000

PLATE 26

P (Phosphorus)



TOTAL NUMBER OF SAMPLES: 2918

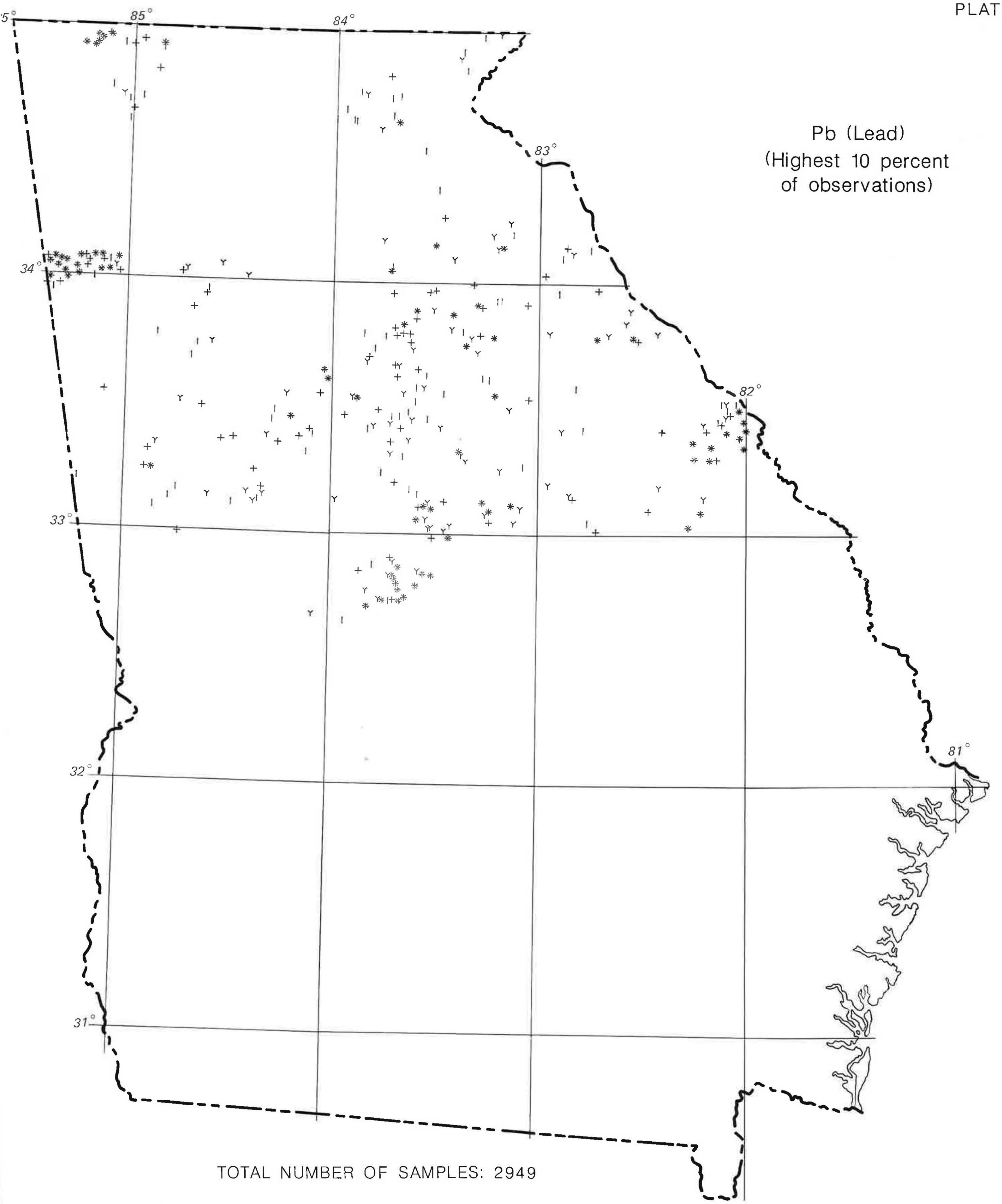
Symbol	PPM	Percent of data
*	11,000 – 800	25.0
+	800 – 500	25.0
Y	500 – 300	25.0
ı	≤300	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 27

Pb (Lead)
(Highest 10 percent
of observations)



TOTAL NUMBER OF SAMPLES: 2949

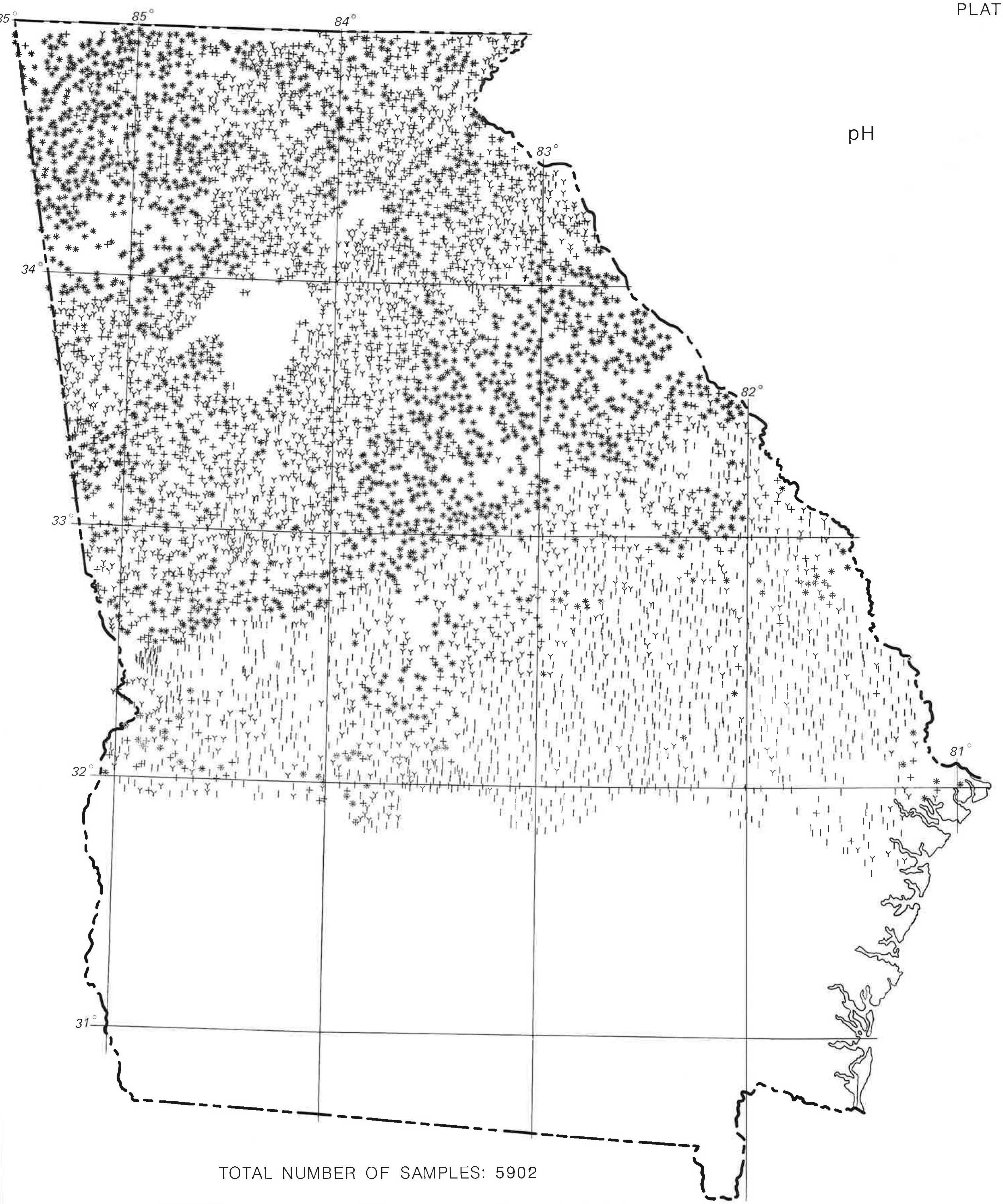
Symbol	PPM	Percent of data
*	600 - 30	2.5
+	30 - 22	2.5
Y	22 - 18	2.5
I	18 - 17	2.5

0 10 25 50 MILES

1:1,785,000

PLATE 28

pH



TOTAL NUMBER OF SAMPLES: 5902

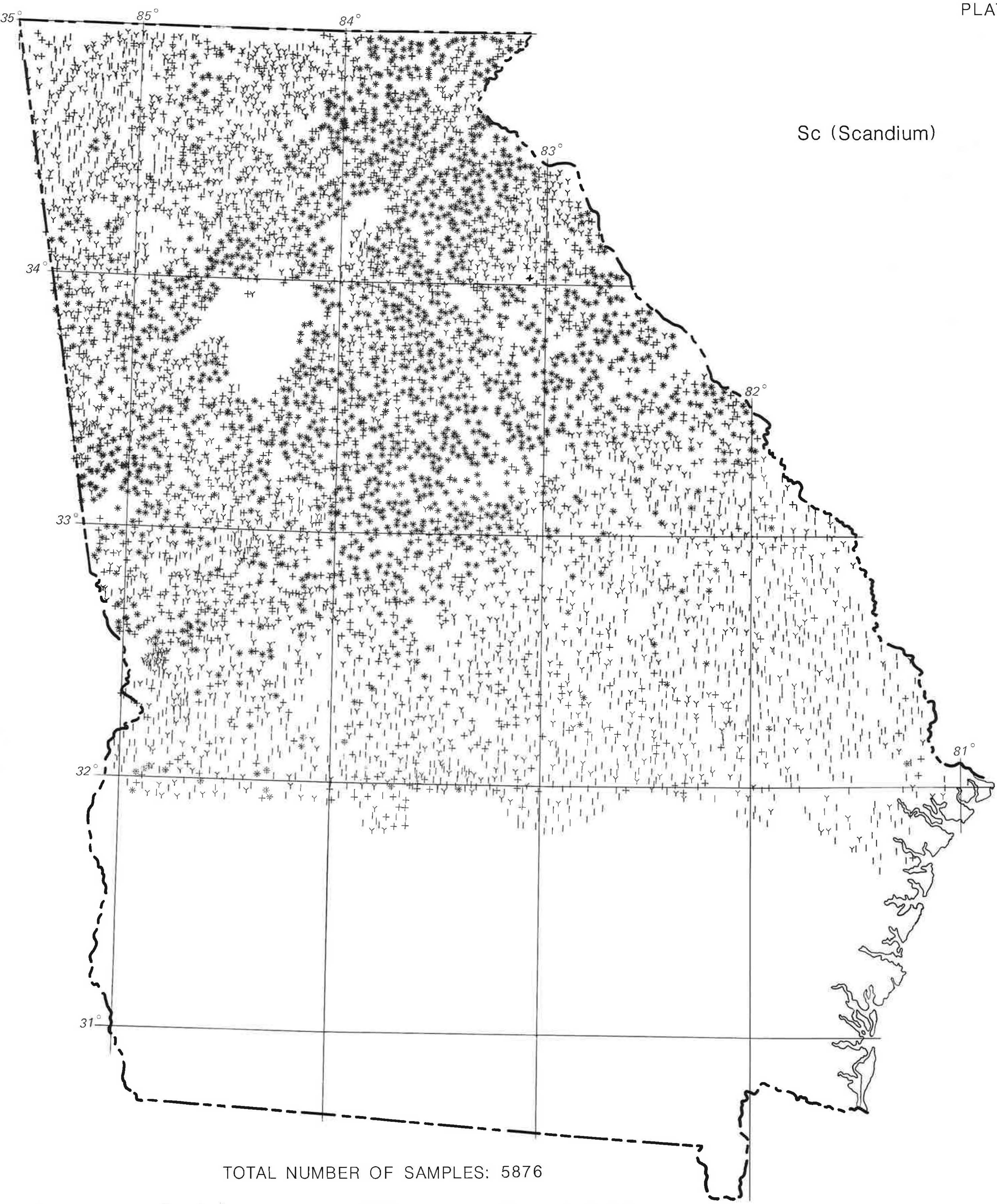
Symbol	pH	Percent of data
*	10.9 – 7.1	25.0
+	7.1 – 6.8	25.0
Y	6.8 – 6.4	25.0
I	6.4 – 3.6	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 29

Sc (Scandium)



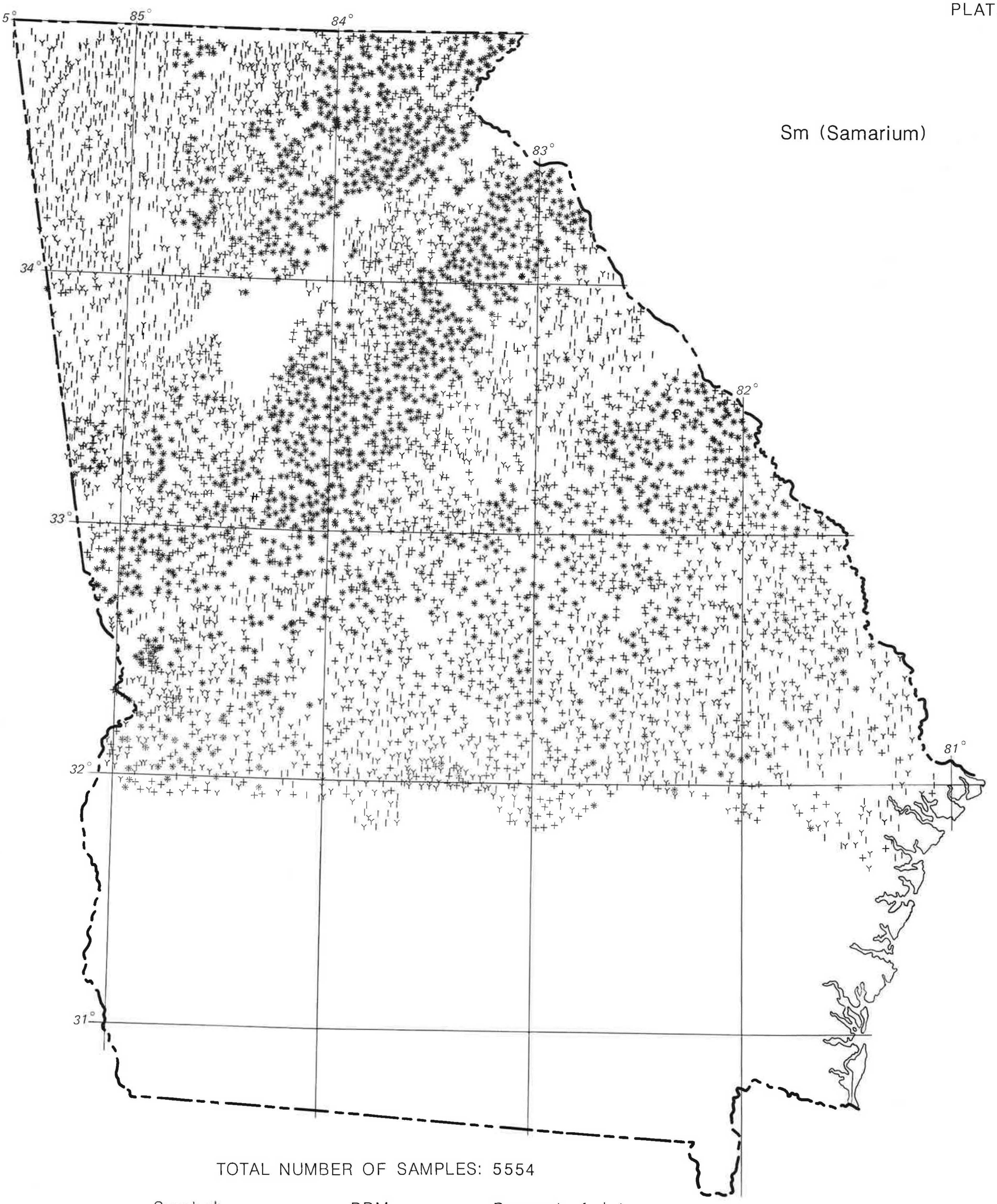
TOTAL NUMBER OF SAMPLES: 5876

Symbol	PPM	Percent of data
*	99.5 – 8.9	25.0
+	8.9 – 5.3	25.0
Y	5.3 – 3.0	25.0
I	≤3.0	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 30

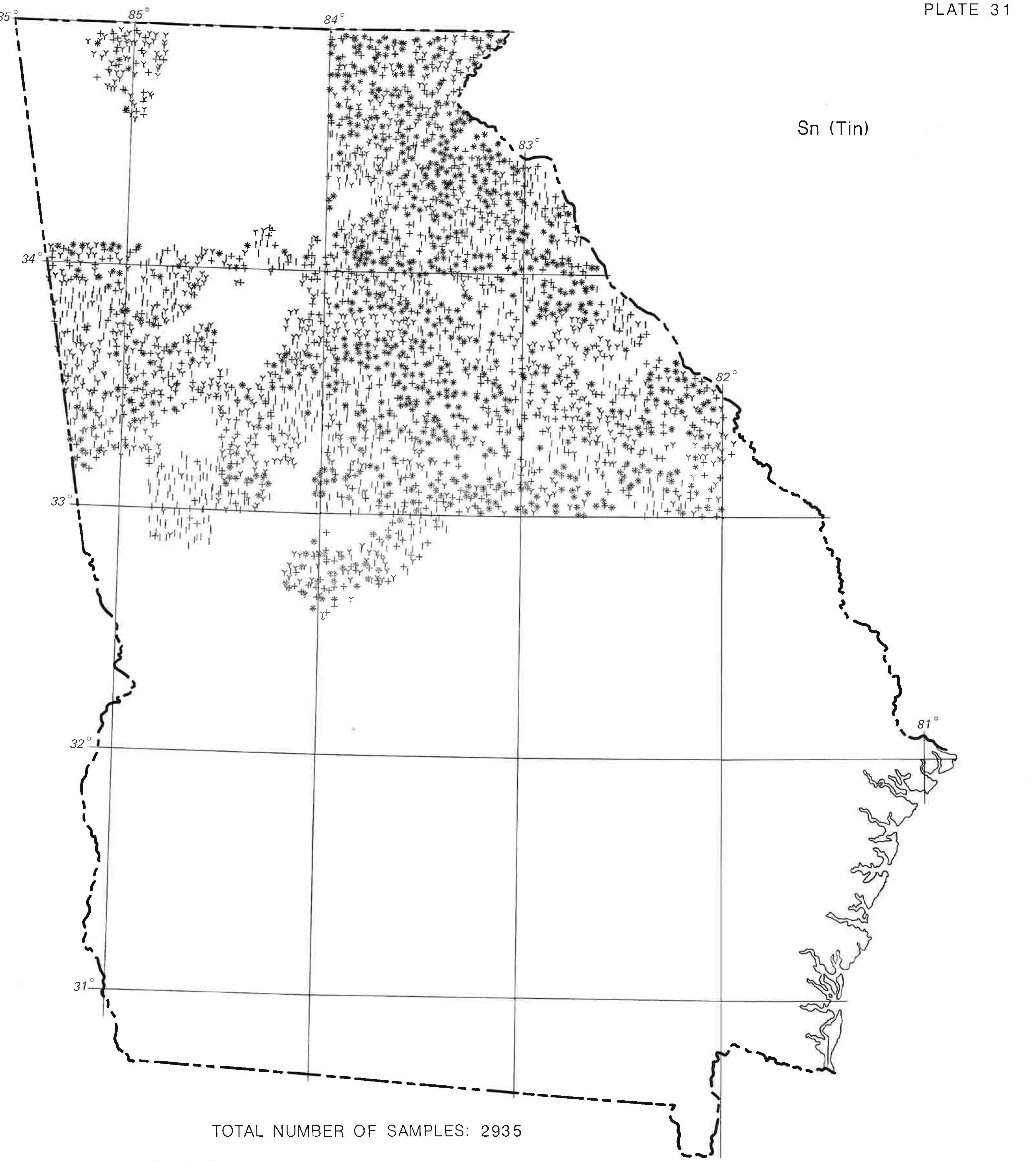


TOTAL NUMBER OF SAMPLES: 5554

Symbol	PPM	Percent of data
*	4558 – 25	25.0
+	25 – 9	25.0
Y	9 – 4	25.0
ı	≤4	25.0

0 10 25 50 MILES

1:1,785,000



TOTAL NUMBER OF SAMPLES: 2935

Symbol	PPM	Percent of data
*	160 – 10	25.0
+	10 – 5	25.0
Y	5 – 3	25.0
ı	≤3	25.0

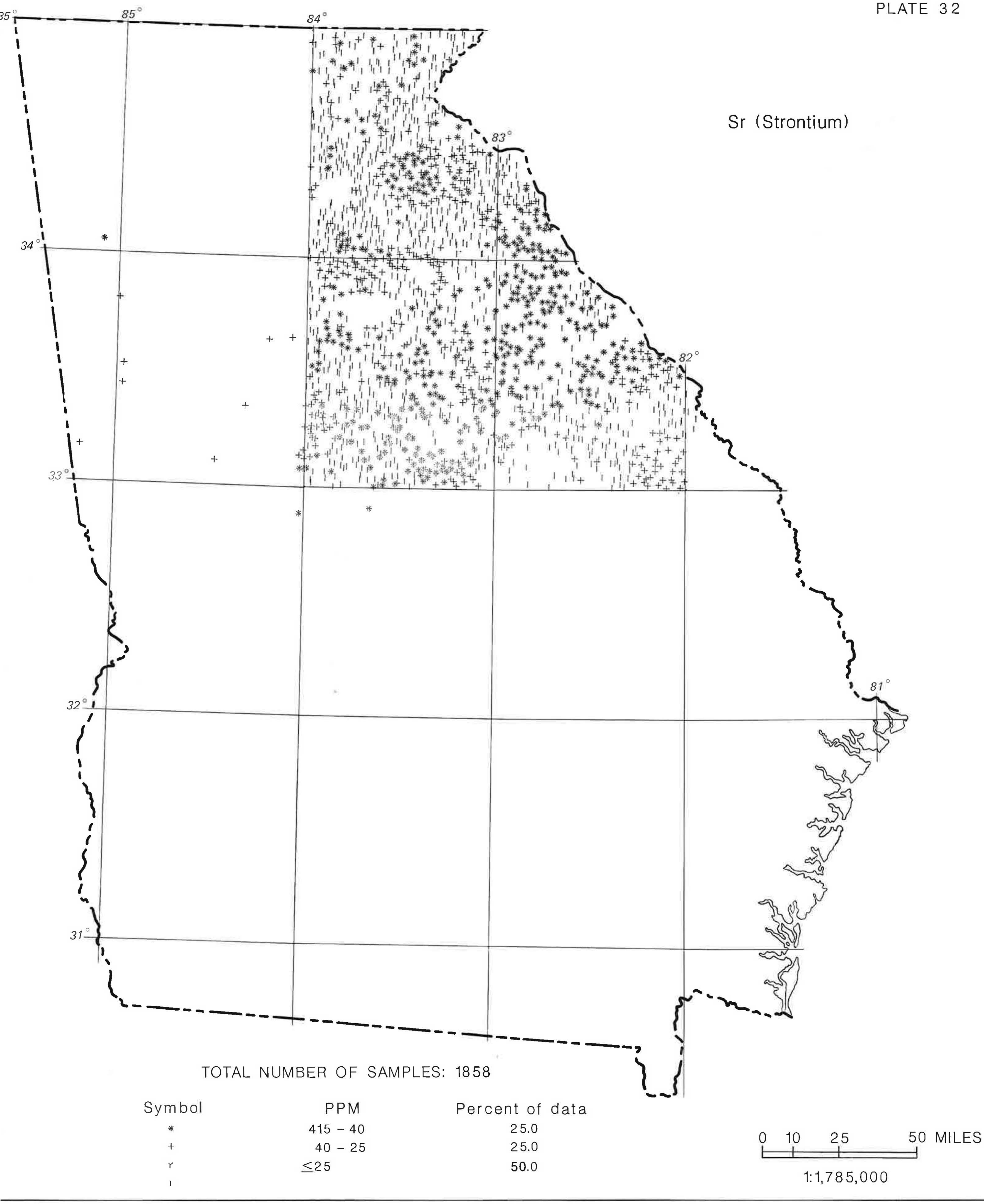
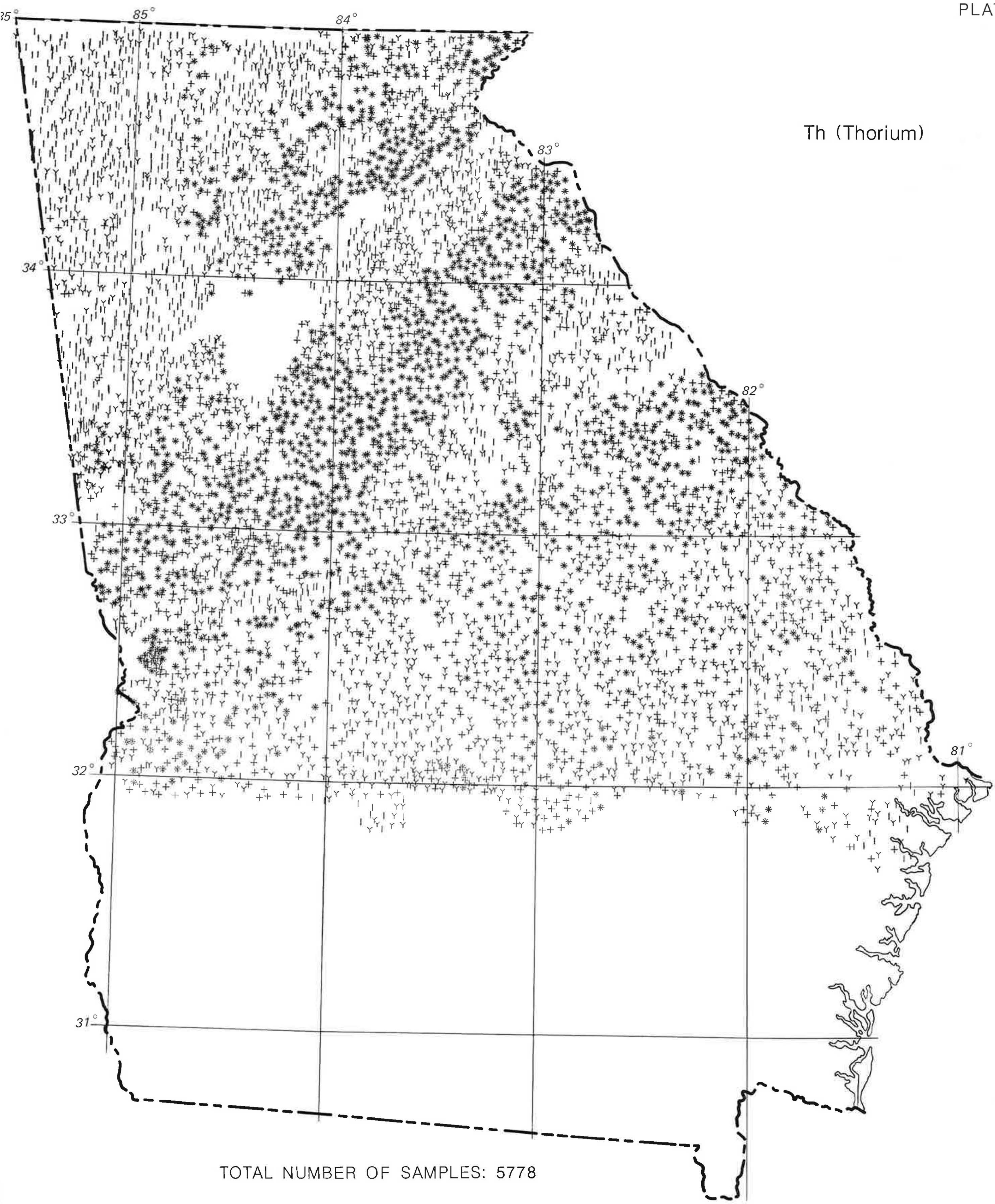

Sr (Strontium)
85°
84°
83°
82°
81°
34°
33°
32°
31°
TOTAL NUMBER OF SAMPLES: 1858
Symbol
PPM
Percent of data
415 - 40
25.0
40 - 25
25.0
≤25
50.0
0
10
25
50 MILES
1:1,785,000

PLATE 33

Th (Thorium)

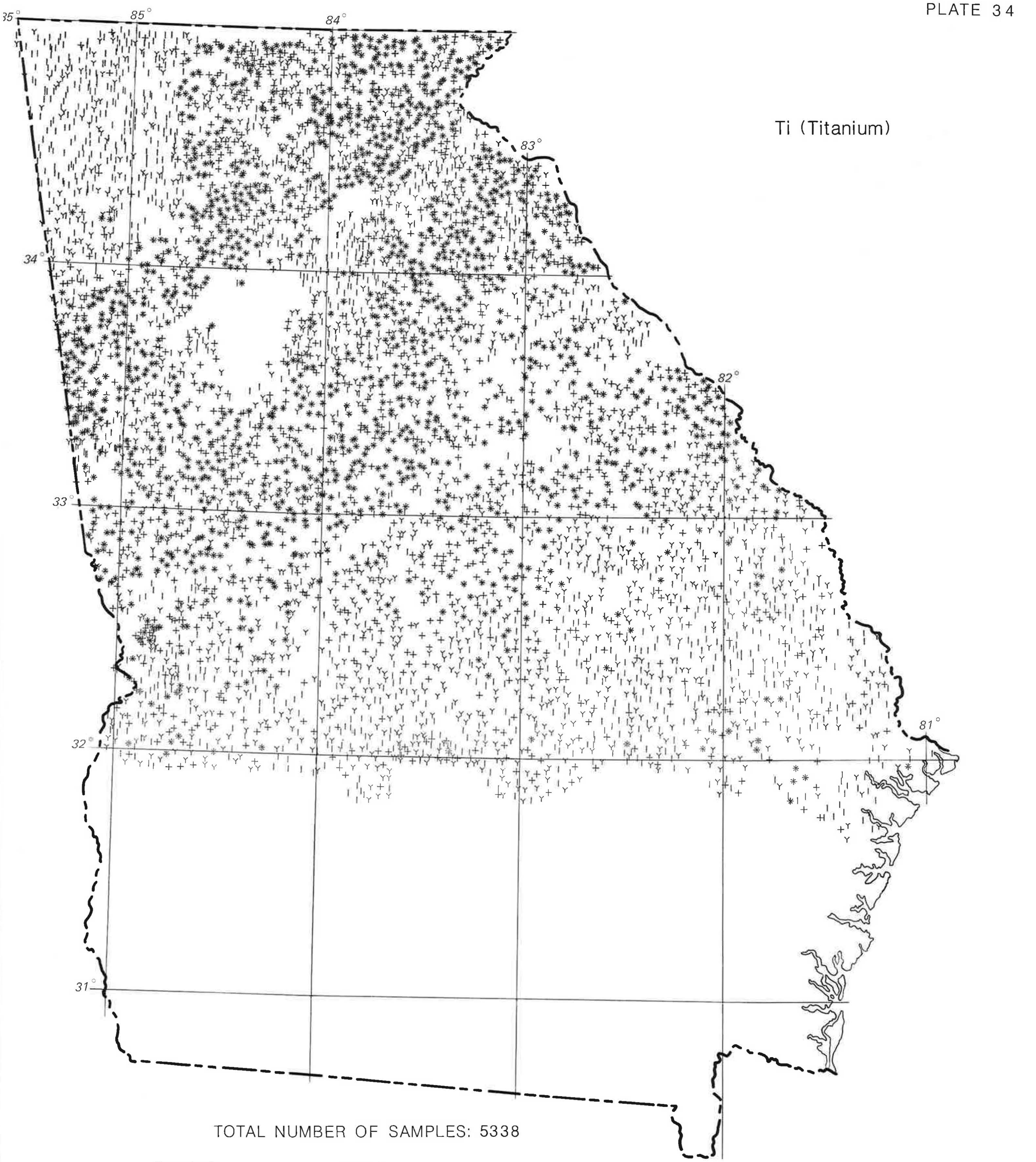


TOTAL NUMBER OF SAMPLES: 5778

Symbol	PPM	Percent of data
*	2066 – 54	25.0
+	54 – 19	25.0
Y	19 – 9	25.0
I	≤9	25.0

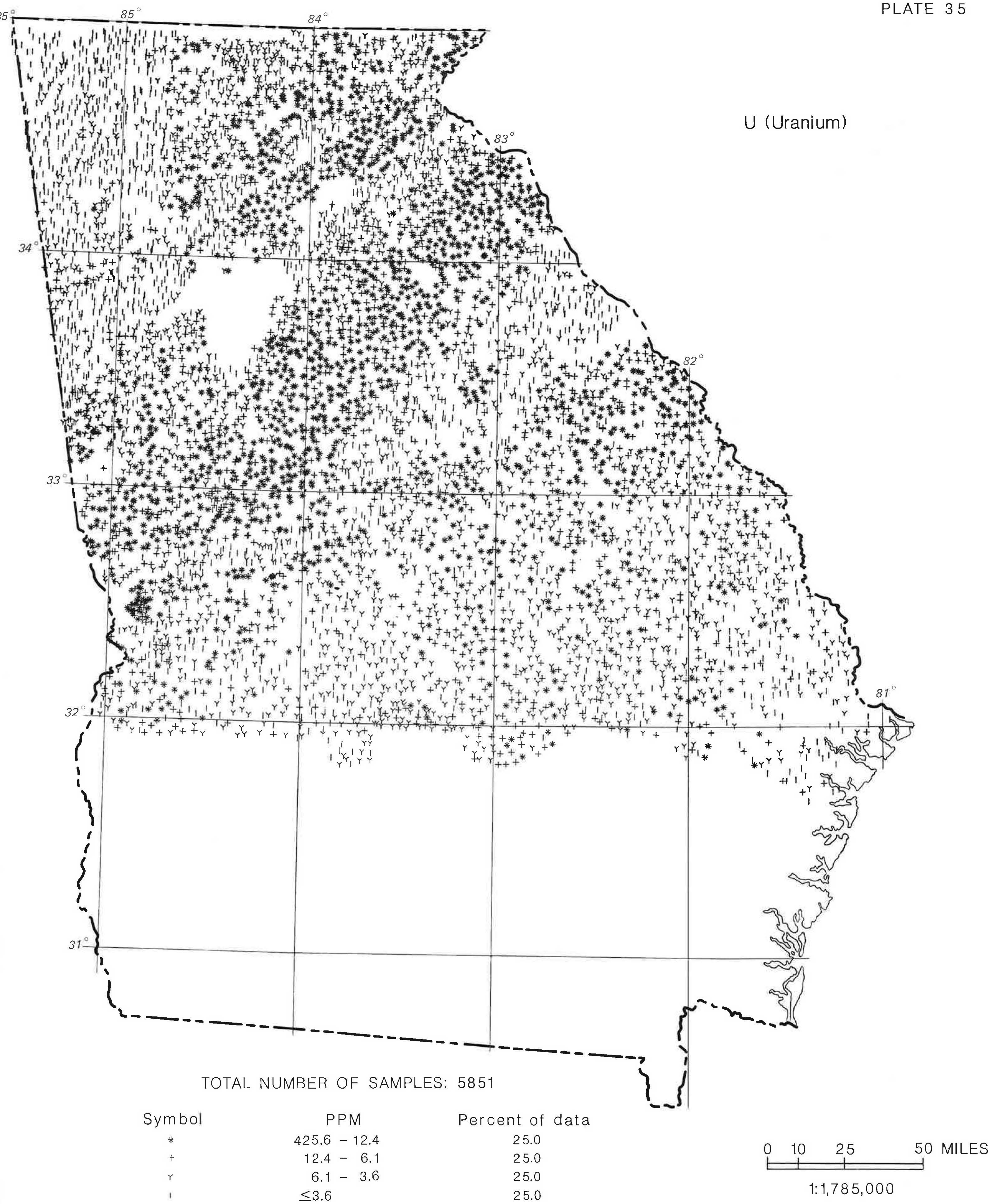
0 10 25 50 MILES

1:1,785,000



TOTAL NUMBER OF SAMPLES: 5338

Symbol	PPM	Percent of data
*	88,100 – 11,700	25.0
+	11,700 – 6500	25.0
Y	6500 – 4200	25.0
ı	≤4200	25.0

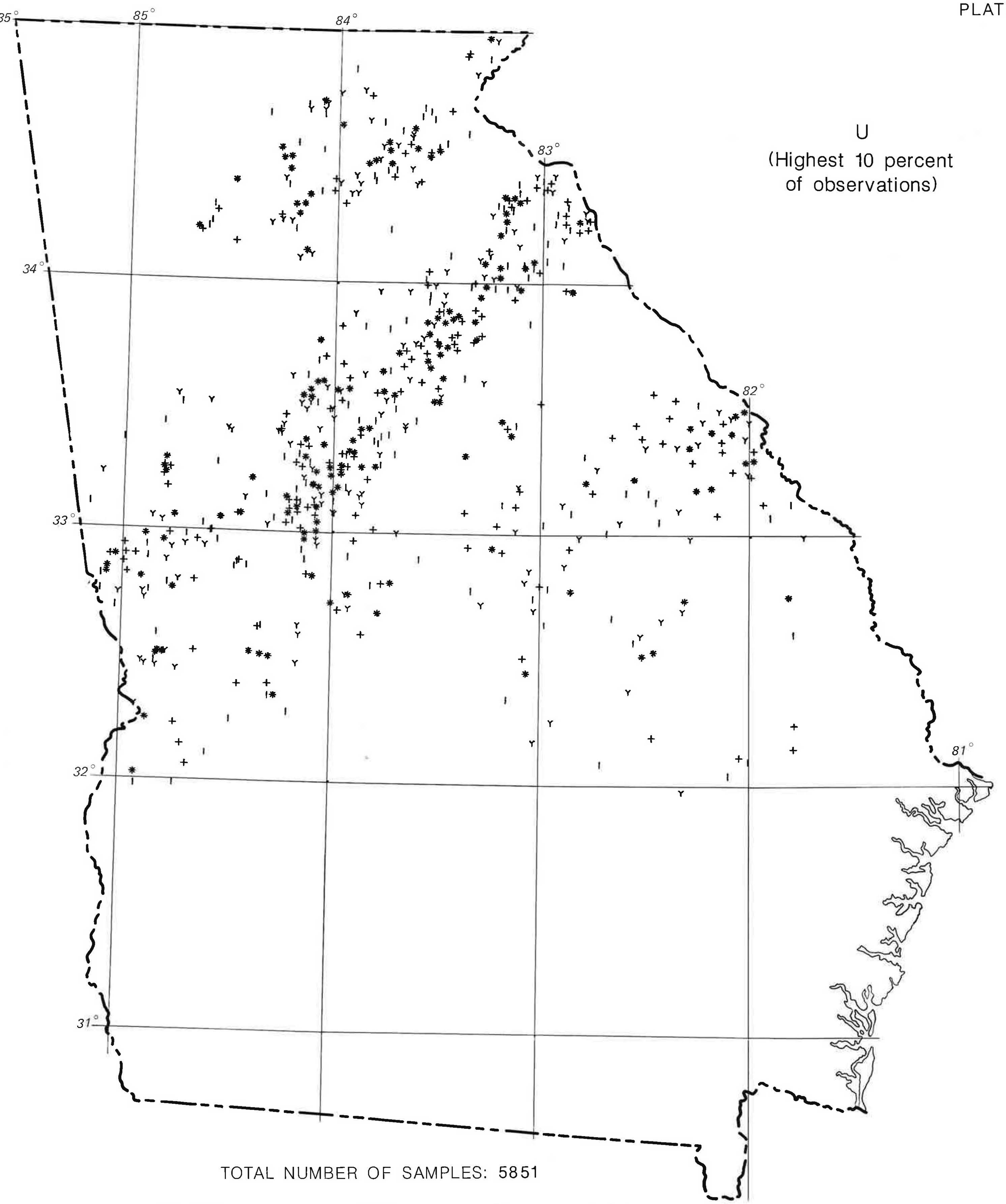


TOTAL NUMBER OF SAMPLES: 5851

Symbol	PPM	Percent of data
*	425.6 – 12.4	25.0
+	12.4 – 6.1	25.0
Y	6.1 – 3.6	25.0
ı	≤3.6	25.0

PLATE 36

U
(Highest 10 percent of observations)



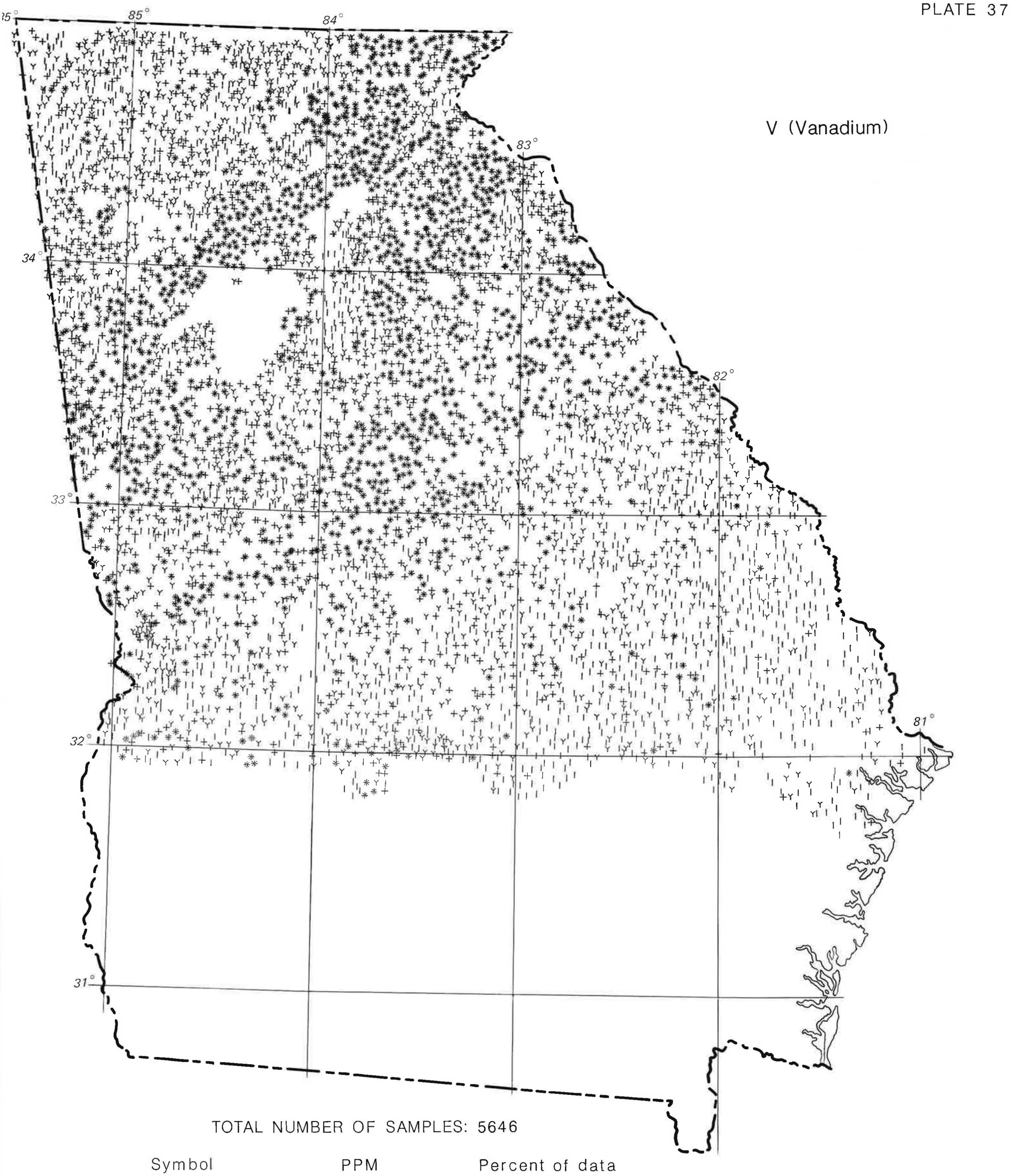
TOTAL NUMBER OF SAMPLES: 5851

Symbol	PPM	Percent of data
*	425.6 – 55.8	2.5
+	55.8 – 38.1	2.5
Y	38.1 – 31.0	2.5
I	31.0 – 25.4	2.5

0 10 25 50 MILES

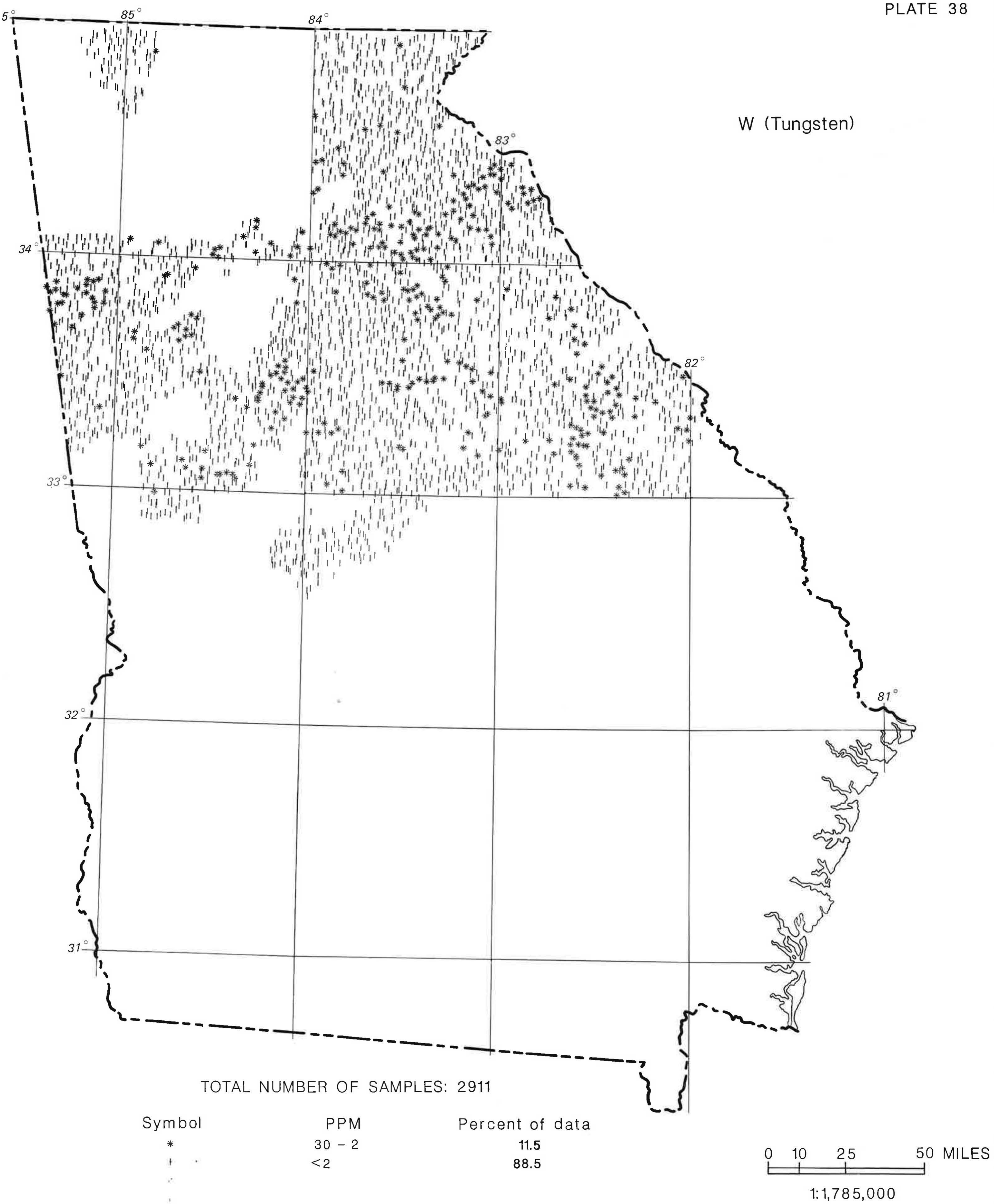
1:1,785,000

PLATE 37



TOTAL NUMBER OF SAMPLES: 5646

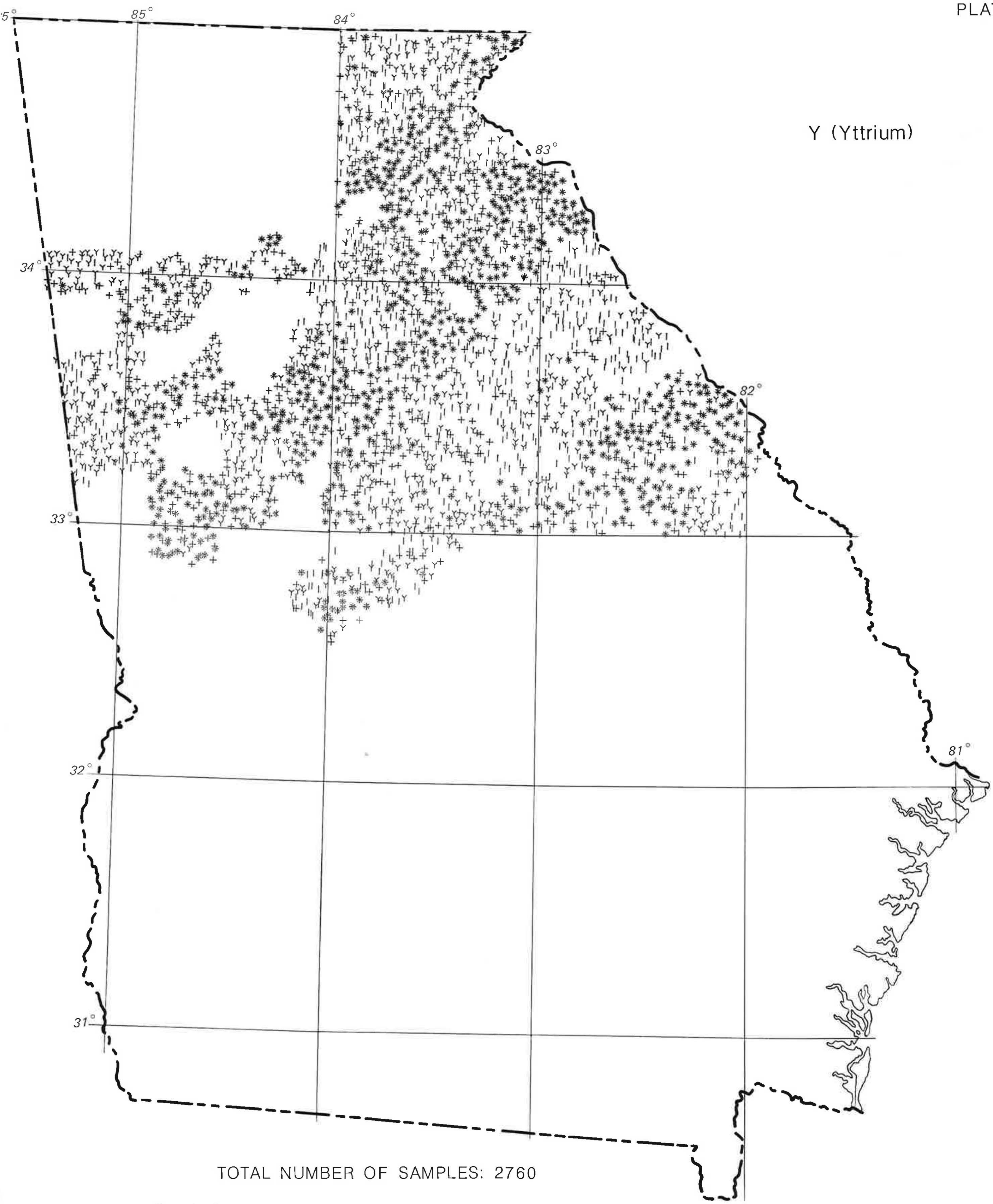
Symbol	PPM	Percent of data
*	1010 – 80	25.0
+	80 – 40	25.0
Y	40 – 20	25.0
ı	≤20	25.0



Symbol	PPM	Percent of data
*	30 − 2	11.5
ǀ	<2	88.5

PLATE 39

Y (Yttrium)



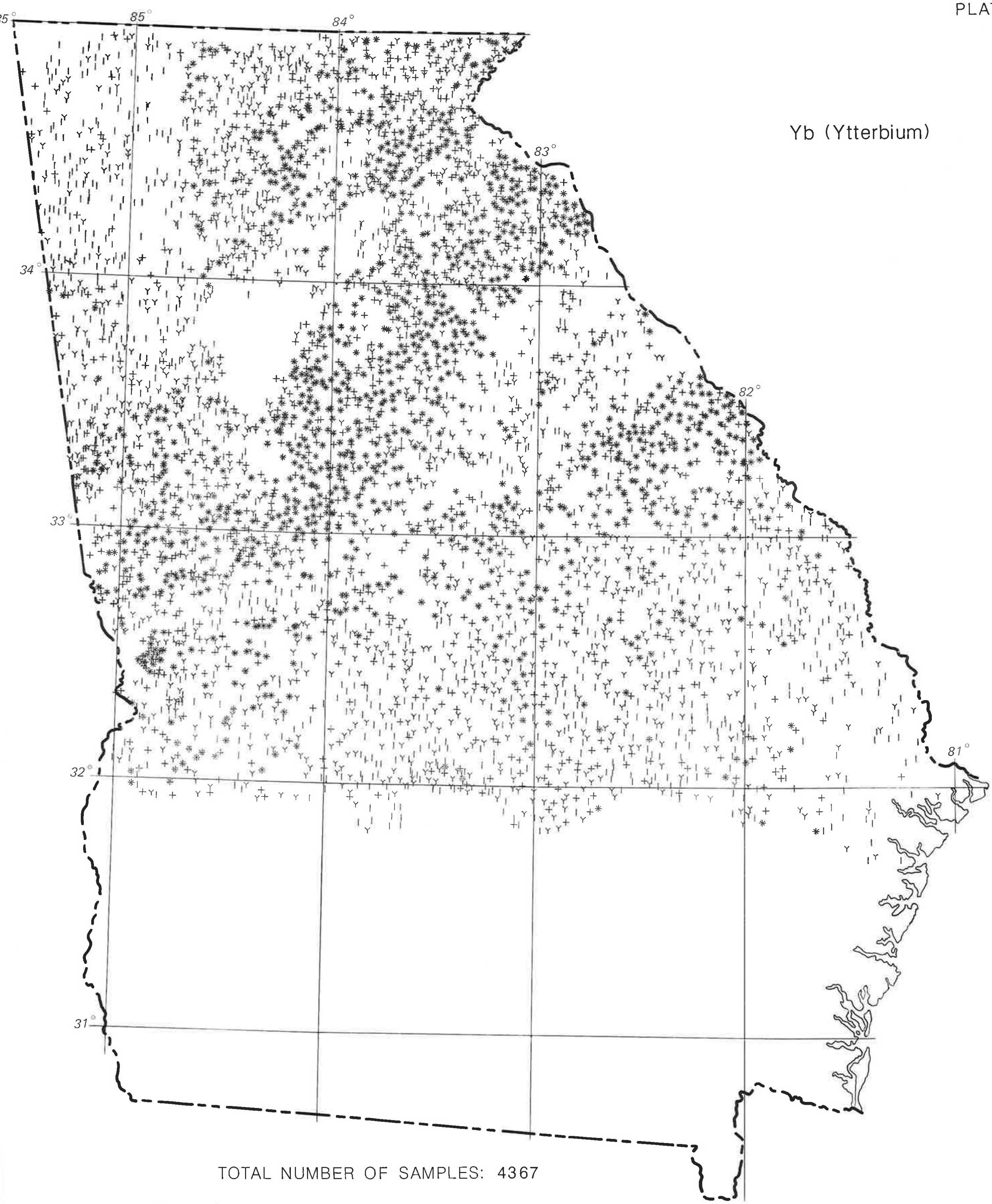
TOTAL NUMBER OF SAMPLES: 2760

Symbol	PPM	Percent of data
*	1070 – 50	25.0
+	50 – 20	25.0
Y	20 – 10	25.0
I	≤10	25.0

0 10 25 50 MILES

1:1,785,000

Yb (Ytterbium)

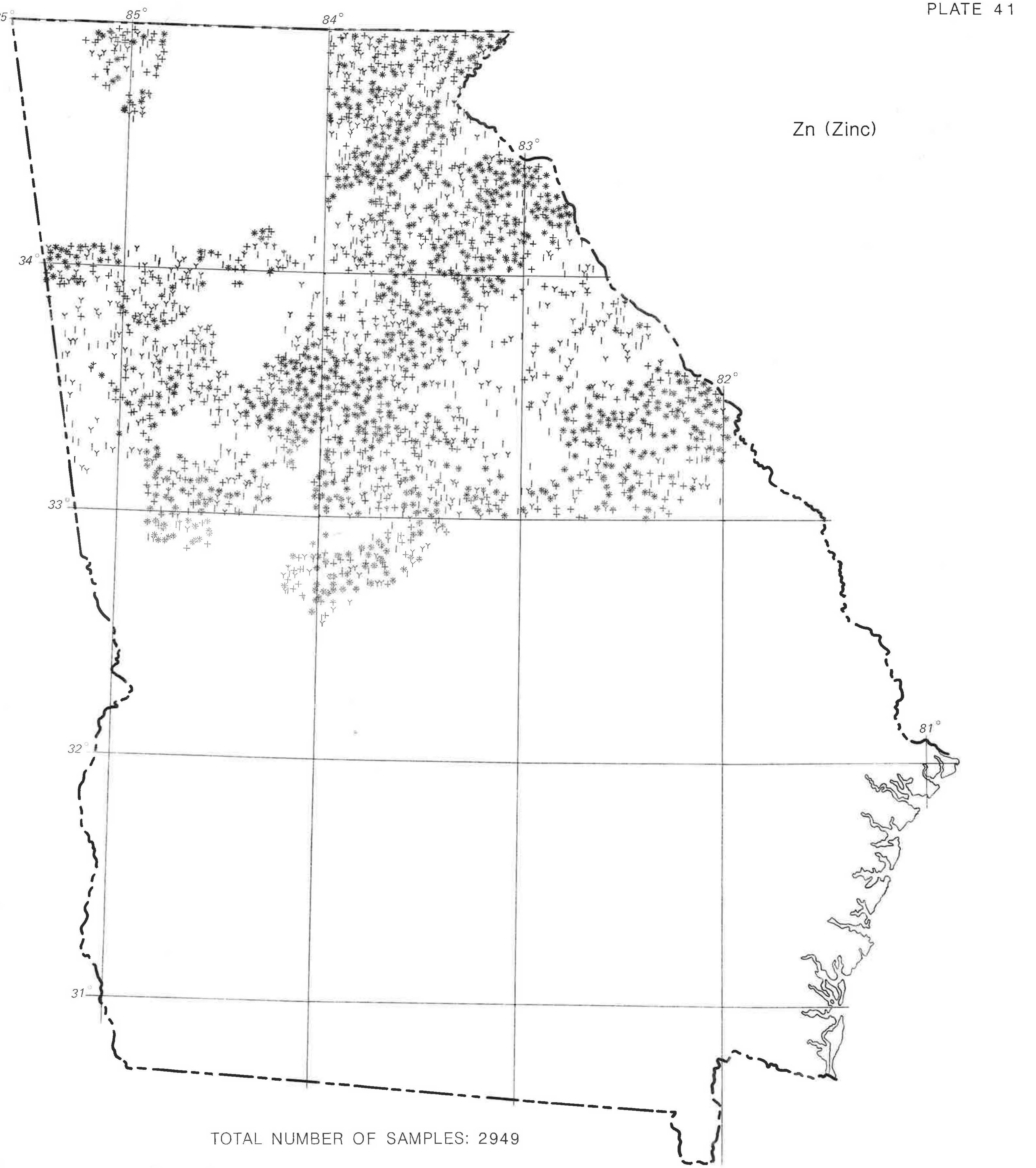


TOTAL NUMBER OF SAMPLES: 4367

Symbol	PPM	Percent of data
*	302.4 – 13.3	25.0
+	13.3 – 7.1	25.0
Y	7.1 – 4.1	25.0
ǀ	≤4.1	25.0

0 10 25 50 MILES

1:1,785,000



TOTAL NUMBER OF SAMPLES: 2949

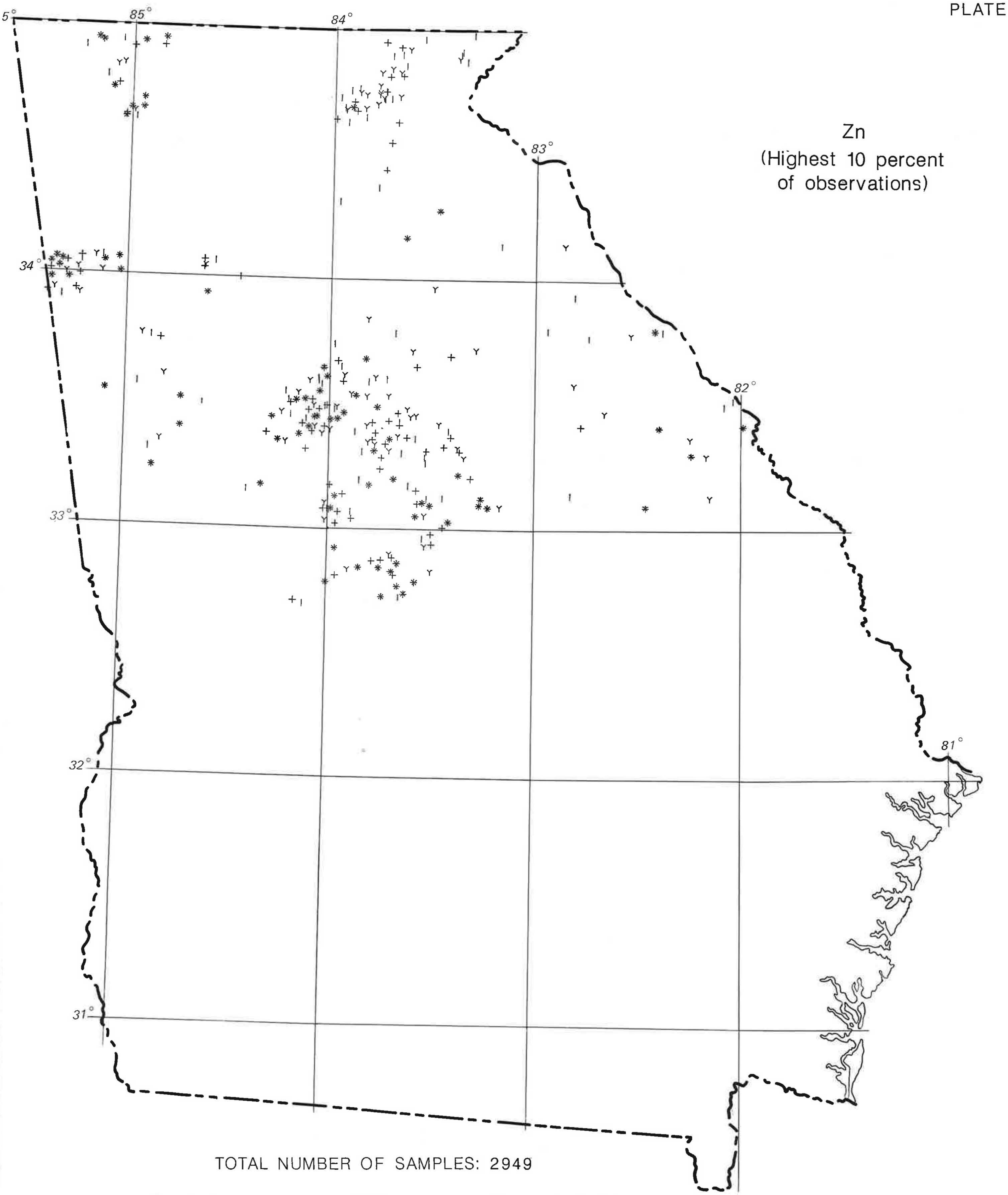
Symbol	PPM	Percent of data
*	1070 – 61	25.0
+	61 – 38	25.0
Y	38 – 25	25.0
ı	≤25	25.0

0 10 25 50 MILES

1:1,785,000

PLATE 42

Zn
(Highest 10 percent of observations)

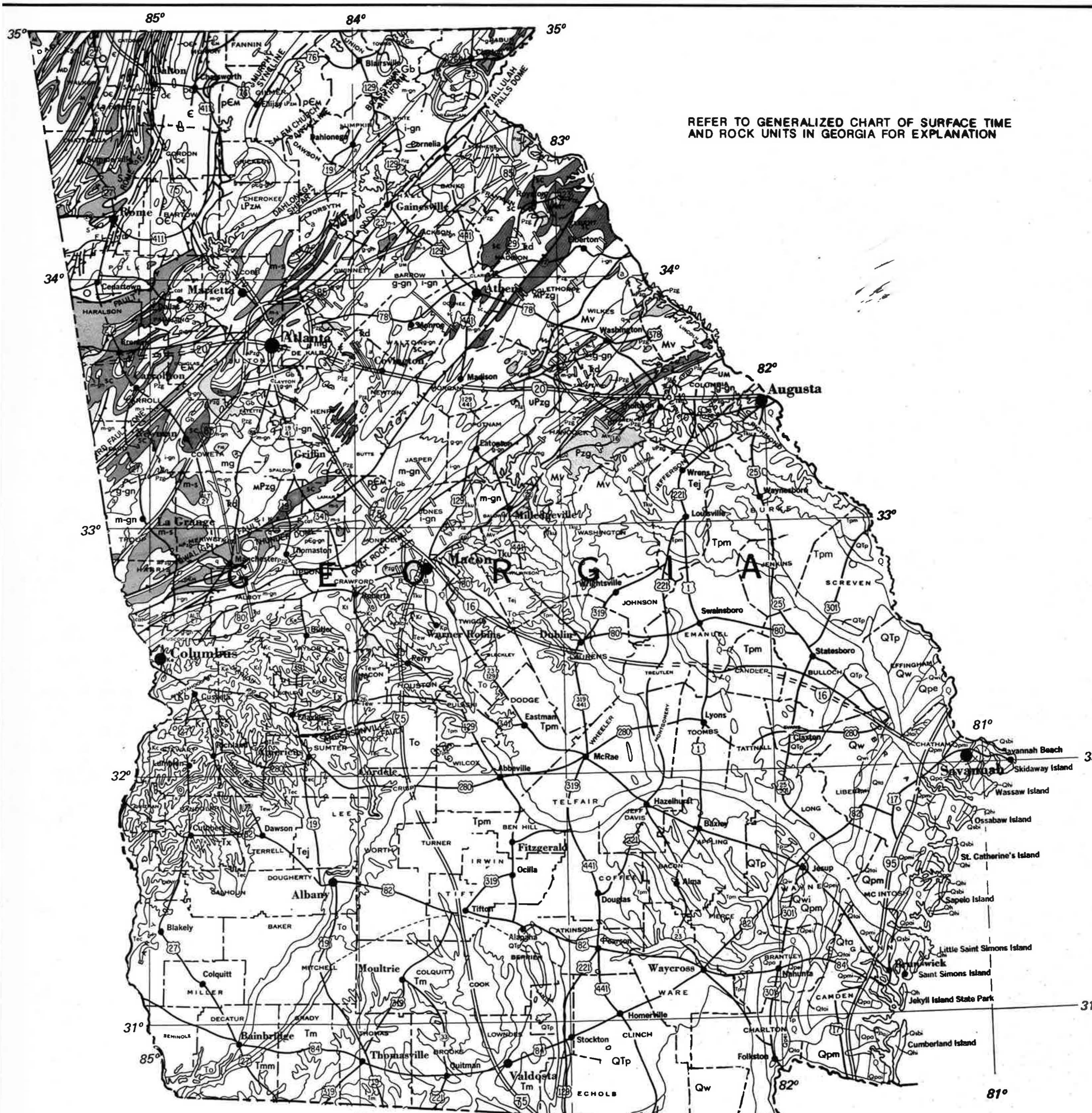


TOTAL NUMBER OF SAMPLES: 2949

Symbol	PPM	Percent of data
*	450 – 95	2.5
+	95 – 70	2.5
Y	70 – 60	2.5
I	60 – 53	2.5

0 10 25 50 MILES

1:1,785,000



REFER TO GENERALIZED CHART OF SURFACE TIME AND ROCK UNITS IN GEORGIA FOR EXPLANATION

Modified from Geological Highway map of the Southeastern Region (Bennison, 1975)