CLAY MINERALOGY

OF THE

HAWTHORNE GROUP

by

John H. Hetrick

Michael S. Friddell

Charles E. Weaver

DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

INFORMATION CIRCULAR 79

CLAY MINERALOGY OF

THE HAWTHORNE GROUP

by

John H. Hetrick, Michael S. Friddell, and Charles E. Weaver

DEPARTMENT OF NATURAL RESOURCES
J. Leonard Ledbetter, Commissioner
ENVIRONMENTAL PROTECTION DIVISION
Harold F. Reheis, Assistant Director
GEORGIA GEOLOGIC SURVEY
William H. McLemore, State Geologist

ATLANTA
1987

INFORMATION CIRCULAR 79

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

APPENDICES

INTRODUCTION

This study is part of a regional investigation of the mineralogy, biostratigraphy, and lithology of the Hawthorne Group. This portion of the investigation consists of the compilation and statistical evaluation of X-ray diffraction data from 713 samples obtained from 28 cores. The results of this study are intended to provide a clay mineral data base from which interpretations concerning the clay mineral origins and distributions can be made. The stratigraphic relationships of the formations which compose the Hawthorne Group and associated formations are shown in Figure 1.

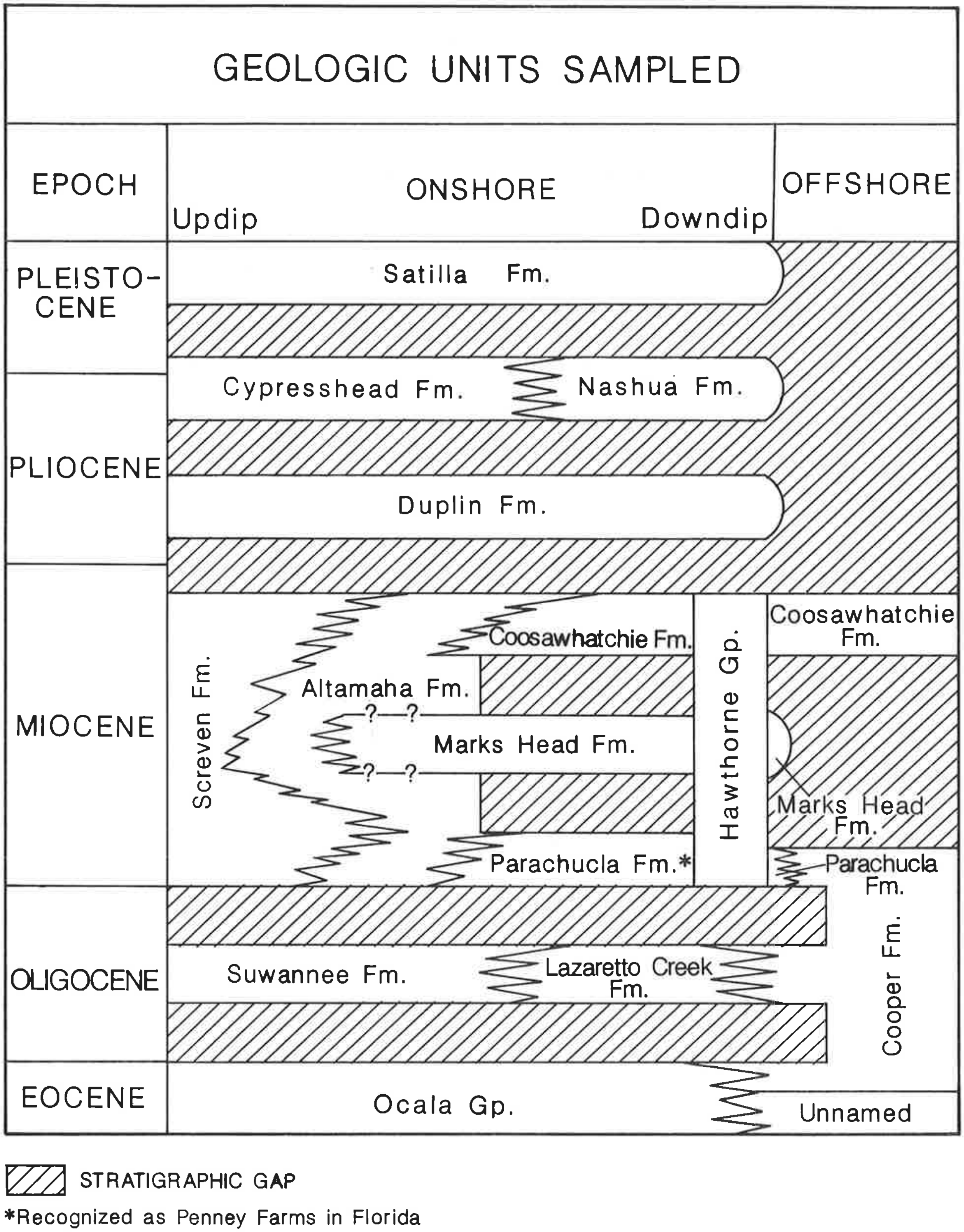

Figure 1. Stratigraphic Correlation Chart (After Huddlestun, in prep.)

STUDY AREA AND PREVIOUS WORK

Interest in the clay mineralogy of the Hawthorne Group has been primarily due to the presence of palygorskite and sepiolite. This is because palygorskite and sepiolite are: (1) major mineral components of Georgia's economic deposits of Fuller's earth (the Fuller's earth is stratigraphically equivalent to the Hawthorne Group), (2) rare from the standpoint of worldwide occurrence, and (3) believed to have formed authigenically.

The study area (Figure 2) was, to some extent, determined by the availability of cores. It was also necessary that the study area include Miocene-age marine sediments, so as to assure the reliability of stratigraphic correlation (by paleontology). Given these constraints, the geographic area investigated did not include the thick economic deposits of palygorskite and sepiolite in southwest Georgia.

The areas from which the cores were taken are southeastern Georgia, southwestern South Carolina, and northeastern Florida. The Georgia cores were taken from Screven, Effingham, Chatham, Bryan, Wayne, Camden, and Charlton Counties. The cores from Florida were taken from Nassau, Baker, Clay, Bradford, Putnam, and Alachua Counties. The single core from South Carolina was from Jasper County. General locations of the cores can be found in Figure 2 and specific locations are given in Appendix C.

Previous investigations of the mineralogy of the Hawthorne Group were made by McClellan (1964), Reynolds (1962), Patterson and Buie (1974), Heron and Johnson (1966), Gremillion (1965), and Weaver and Beck (1977). Semiquantitative estimation of clay mineral abundances are included in the studies of McClellan (1964), Weaver and Beck (1977), and Heron and Johnson (1966). Reynolds (1962) in his study

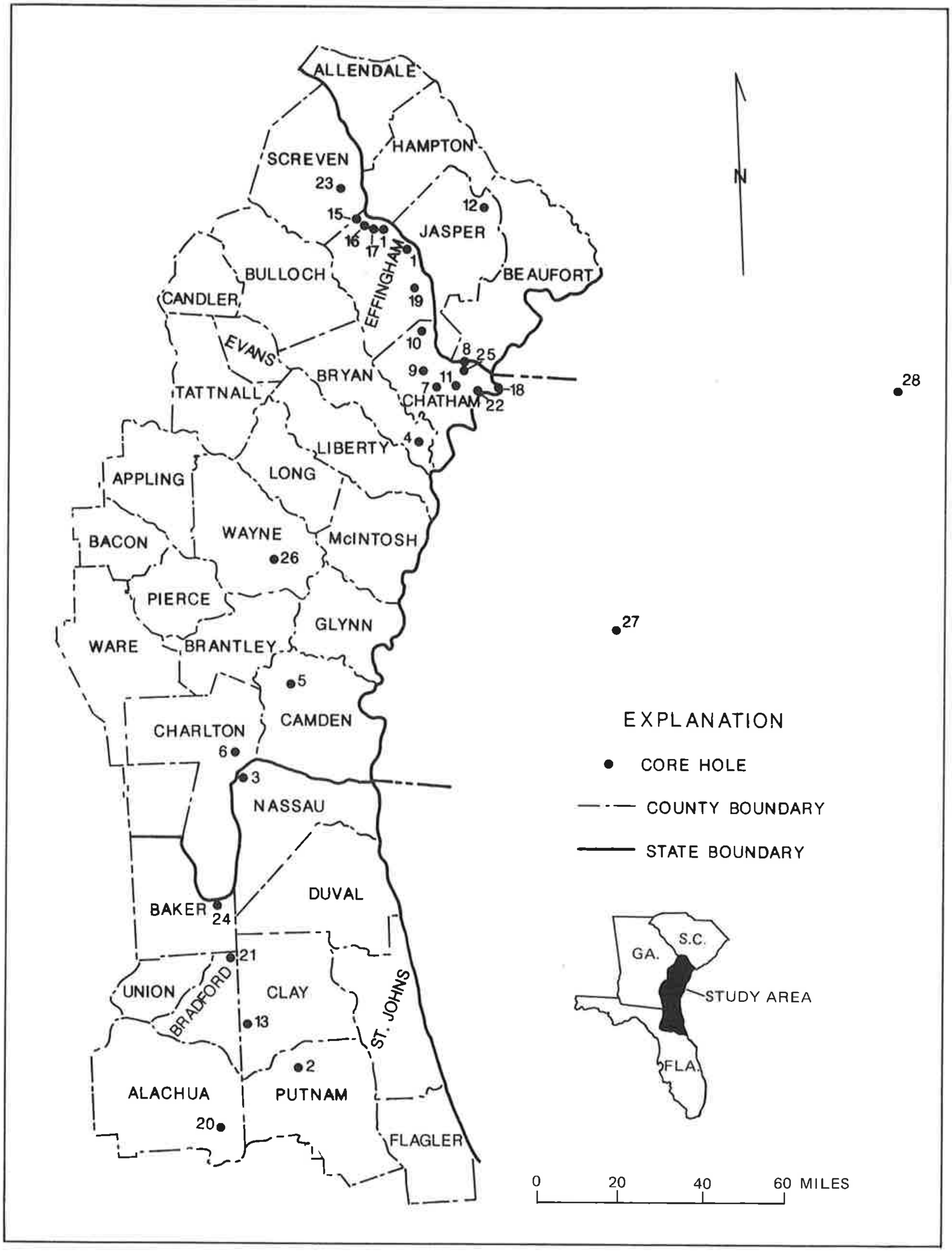

Figure 2. Location Map of Cores.

included relative abundances of clays based on visual estimations from diffractograms. A listing of the minerals found in the Hawthorne Group by previous investigators is given in Table 1. The most comprehensive of the above studies is that of Weaver and Beck, (1977) who conclude that...."palygorskite and sepiolite were formed in brackish water probably under schizohaline conditions. Sepiolite was deposited in the fresher-water environment."

LABORATORY METHODS

The stratigraphic assignments and samples of the cores were provided by Paul Huddlestun. Approximately one-half of the samples were processed and analyzed by personnel at the Georgia Institute of Technology. The remainder of the analyses were performed by Georgia Geologic Survey personnel using the same laboratory techniques as were used by Georgia Institute of Technology personnel. Each sample was crushed to a powder and dispersed in deionized water for approximately one minute with a blender. If the suspended clay flocculated after this dispersion, several ml of calgon solution (4mg/100 ml H_2O) were added and the suspension placed in an ultrasonic bath for several minutes. After a nonflocculating dispersion of the clay was achieved, a gravity separation of the particles smaller than two microns was made. In accordance with the equation of Folk (1955, p. 40), after a settling time of 13 minutes, clay from the top 0.3 cm of the suspension was removed with an eyedropper and deposited on a glass microscope slide.

Each oriented clay slide was saturated with ethylene glycol vapor and then examined by X-ray diffraction. As the 001 diffraction peak areas for kaolinite, illite and smectite* and the 110 diffraction peak areas of palygorskite, and sepiolite are related to the compositional abundances of these minerals (Carrol, 1970, p.65), the areas of these specific peaks were measured using a planimeter and the presence of other minerals noted. In diffractograms where the palygorskite (110) peak overlaps the illite (001) peak or the sepiolite (110) peak, the peak areas were visually partitioned.

To correct for the intrinsically low diffraction intensities of illite, kaolinite, palygorskite, and sepiolite, their peak areas were multiplied by mineral specific constants in order to approximate mineral abundance. The constants used for the correction of the illite and kaolinite peak areas are 9.4 and 7.1 respectively (Heath and Pisias, 1979) and the palygorskite and sepiolite constants are 3.0 and 2.0 respectively (Weaver and Beck, 1977). Because crystallinity, particle size, and chemical composition affect the accuracy of such analyses, truly quantitative values for the current study would have required that new constants be established specifically for the sediments examined in this study. Even if such constants had been developed, it is possible the parameters that affect the constants (crystallinity, particle size, and chemical composition) would vary enough with respect to depth (time) to invalidate quantitative measurements of clay mineralogy. Since the establishment of these constants was not feasible, the percentage mineral composition of the clay fractions is semiquantitative.

---

*smectite is the name of the group of expandable clay minerals which includes montmorillonite.

TABLE 1. MINERALS REPORTED FROM THE HAWTHORNE GROUP SEDIMENTS BY PREVIOUS WORKERS

CLAY MINERALS	OTHER MINERALS		
kaolinite[1,2,3,4,5,6]*	calcite[1,3,4,5,6]		sillimanite[3,6]
illite[1,2,4,5,6]	dolomite[1,3,4,5,6]		rutile[3,6]
palygorskite (attapulgite)[1,2,3,4,5,6]	phosphate minerals[1,3,4,5,6]		ilmenite[3]
sepiolite[1,2,3,4,5,6]	microcline[1,6]	feldspar[2,3,5]	zircon[6]
smectite (montmorillonite)[1,2,3,4,5,6]	orthoclase[1,6]		tourmaline[6]
Fe-chlorite[6]	opal, cristobalite[1,3,5,6]		staurolite[6]
	chert[2]		kyanite[6]
	pyrite[2]		biotite[6]
	garnet[3]		muscovite[6]
			Clinoptilolite[4,6]

* 1 - McClellan (1964), 2 - Reynolds (1962), 3 - Patterson and Buie (1974), 4 - Heron and Johnson (1966), 5 - Gremillion (1965), 6 - Weaver and Beck (1977)

The percentage of each clay mineral in each sample was calculated from the corrected diffraction peak areas of the clay-size fraction. Semi-quantitative clay mineral compositions as well as the occurrences of non-clay minerals are listed in Appendix A. The precision of this method (one standard deviation) is ± 2.2, ± 2.9, and ± 1.5 percent for smectite, illite, and kaolinite respectively.

RESULTS

The geologic units involved in the analyses, the number of samples examined, and the mean clay mineral compositions are given in Table 2. Similar information is given in Table 3 for geologic units for which less than 20 samples were available. Comparisons of the mean clay mineral compositions of various geologic units suggest that there are some obvious clay mineralogy differences between the units, such as, the Marks Head Formation being high in palygorskite. However, examination of the stratigraphic distribution of clay mineral compositions (Sm = smectite, P = palygorskite, S = sepiolite, I = illite, K = kaolinite, C = chlorite) in Figures 3 through 30 indicates that there is a high variability of clay mineral composition that is not obviously related to stratigraphic position. Thus, in order to determine which mean clay mineral compositions are significantly different, statistical analyses were performed.

STATISTICAL ANALYSIS

In the statistical analysis the clay mineral composition data were grouped on the basis of stratigraphic occurrence (formations or groups). No consideration was given to the core from which a sample was obtained. Data for any geologic unit which did not contain 20 samples were not analyzed. The cells, stratigraphic horizons, number

TABLE 2. CLAY MINERAL COMPOSITION MEANS FOR SAMPLES STATISTICALLY ANALYZED

	Geologic Unit	Number of Samples	Means (%)				
			Smectite	Palygorskite	Sepiolite	Illite	Kaolinite
	Pleistocene Formations (2)*	33	37.5	4.8	0.0	14.5	43.0**
	Pliocene Formations (3)	41	27.5	4.5	3.8	13.9	49.8**
Marine Hawthorne	Coosawhatchie Formations (6)	233	42.9	14.1	7.4	32.5	3.1
Marine Hawthorne	Marks Head Formation (7)	220	31.4	41.2	14.6	10.2	2.1
Marine Hawthorne	Parachucla*** Formation (8)	120	54.6	12.2	6.8	18.7	7.7
Marginal Marine-Nonmarine Hawthorne	Altamaha Formation (11)	21	62.0	1.5	0.0	11.9	24.6**
	Oligocene Formations (9)	22	67.4	9.9	4.4	14.6	3.7

* Number used for formation identification
** Also contains chlorite
*** Recognized as Penney Farms Formation in Florida

TABLE 3. CLAY MINERAL COMPOSITION MEANS FOR SAMPLES NOT STATISTICALLY ANALYZED

	Geologic Unit	Number of Samples	Means (%)				
			Smectite	Palygorskite	Sepiolite	Illite	Kaolinite
Marine Hawthorne	Hawthorne (5)* Undifferentiated	3	26.9	1.2	0.0	54.2	17.7
	Hawthorne Equivalent (10)	11	17.3	58.6	4.0	6.5	13.6
	Upper Miocene Hawthorne Equivalent (12)	7	15.9	21.4	0.0	31.2	31.5
Nonmarine Hawthorne	Screven Formation (4)	2	0.0	0.0	0.0	0.0	97.5**

* Number used for formation identification
** Also contains chlorite

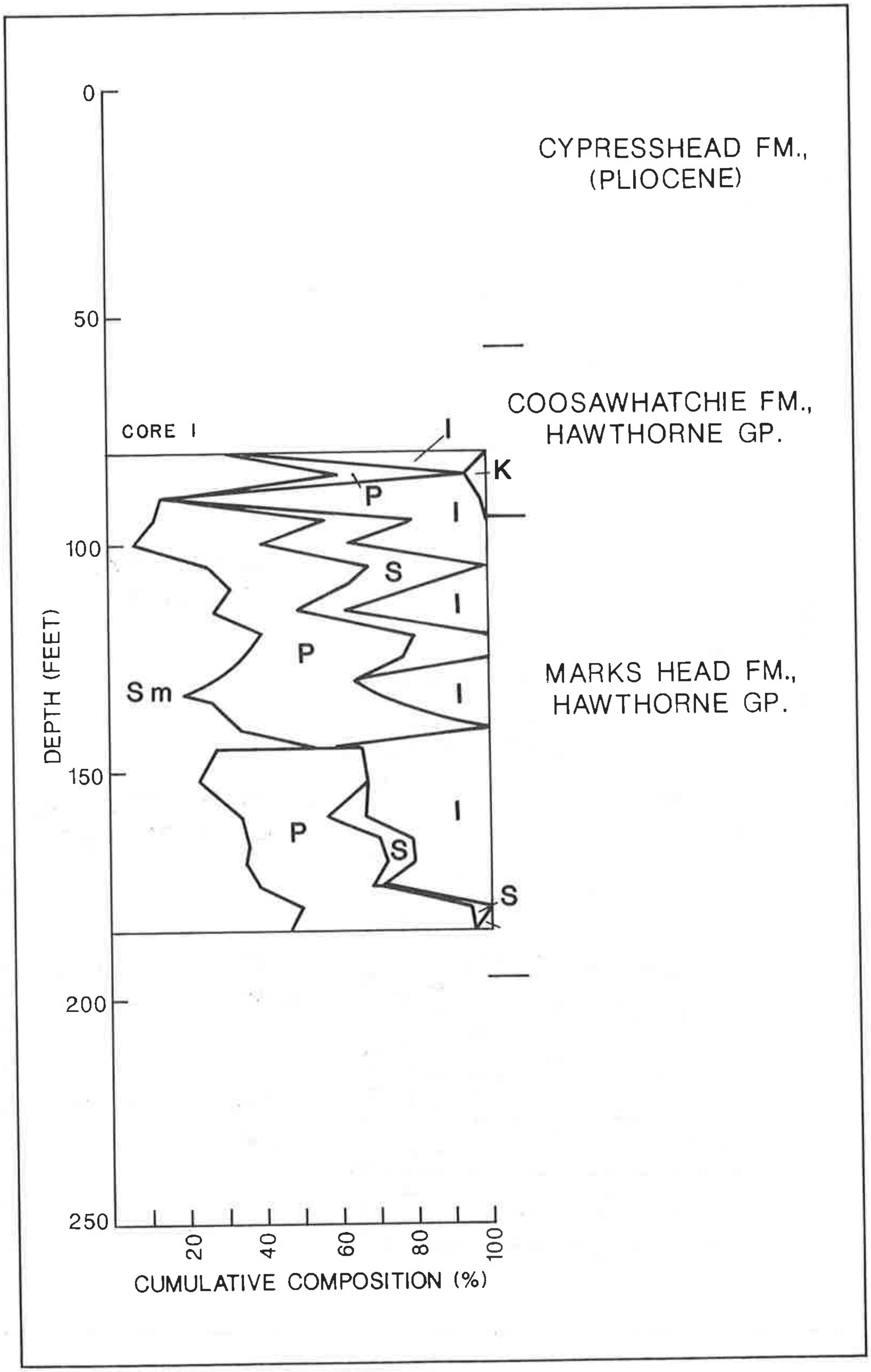

Figure 3. Clay Minerals Distribution in Core 1 (Georgia Power B-41). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

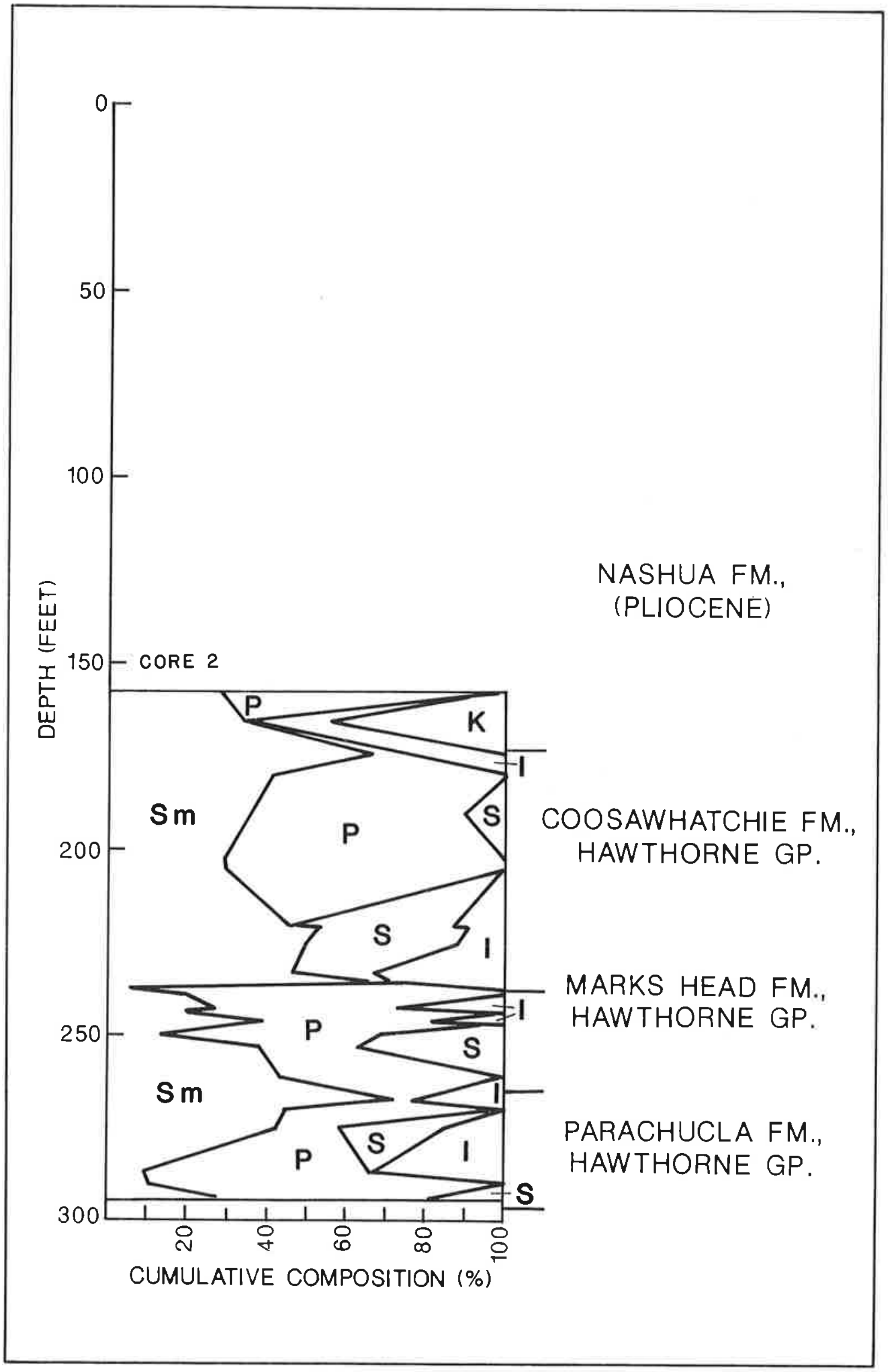

Figure 4. Clay Minerals Distribution in Core 2 (Fla. Bureau of Geology W-8400). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

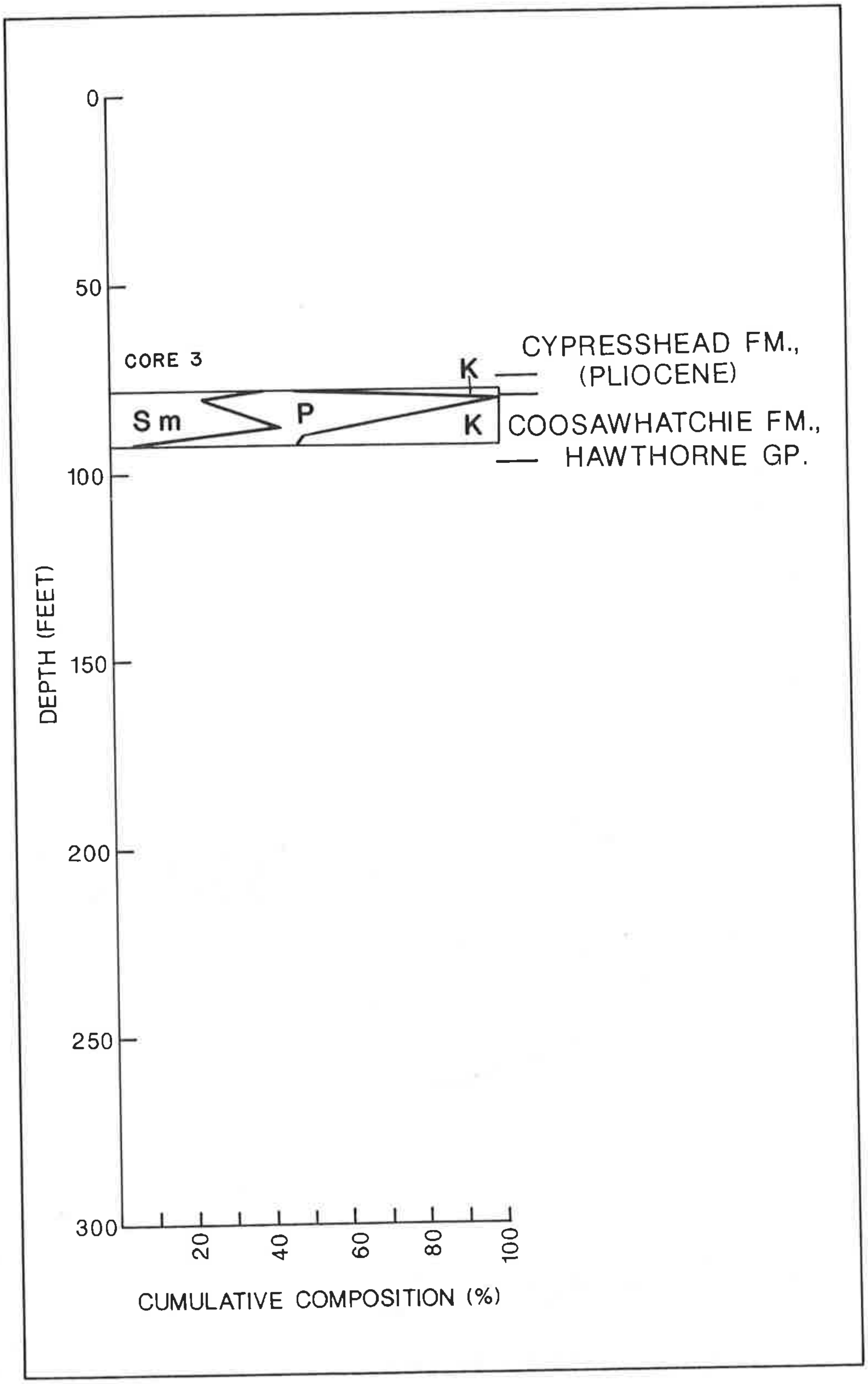

Figure 5. Clay Minerals Distribution in Core 3 (Fla. Bureau of Geology W-10482). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

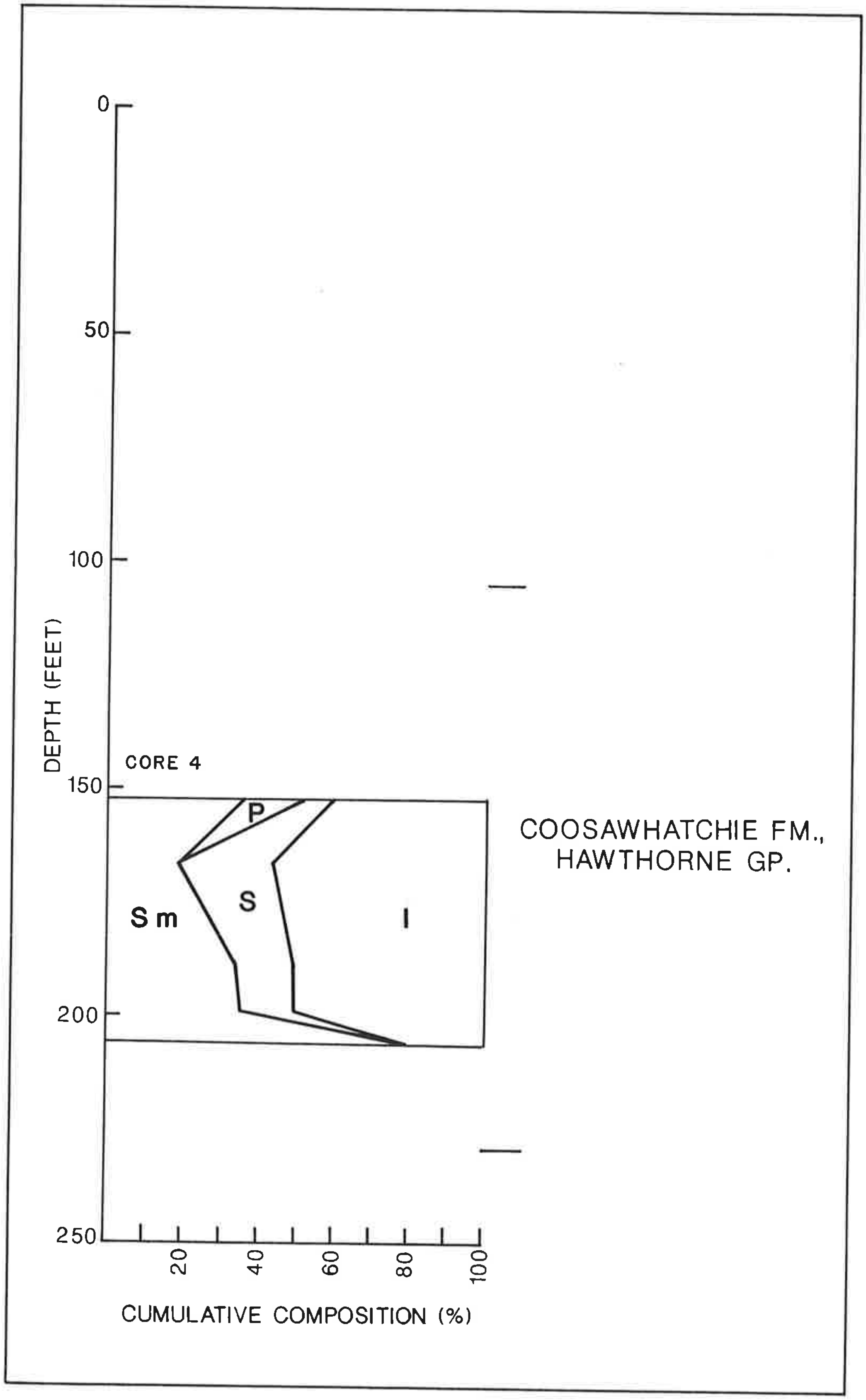

Figure 6. Clay Minerals Distribution in Core 4 (GGS 1337, Bryan 2). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

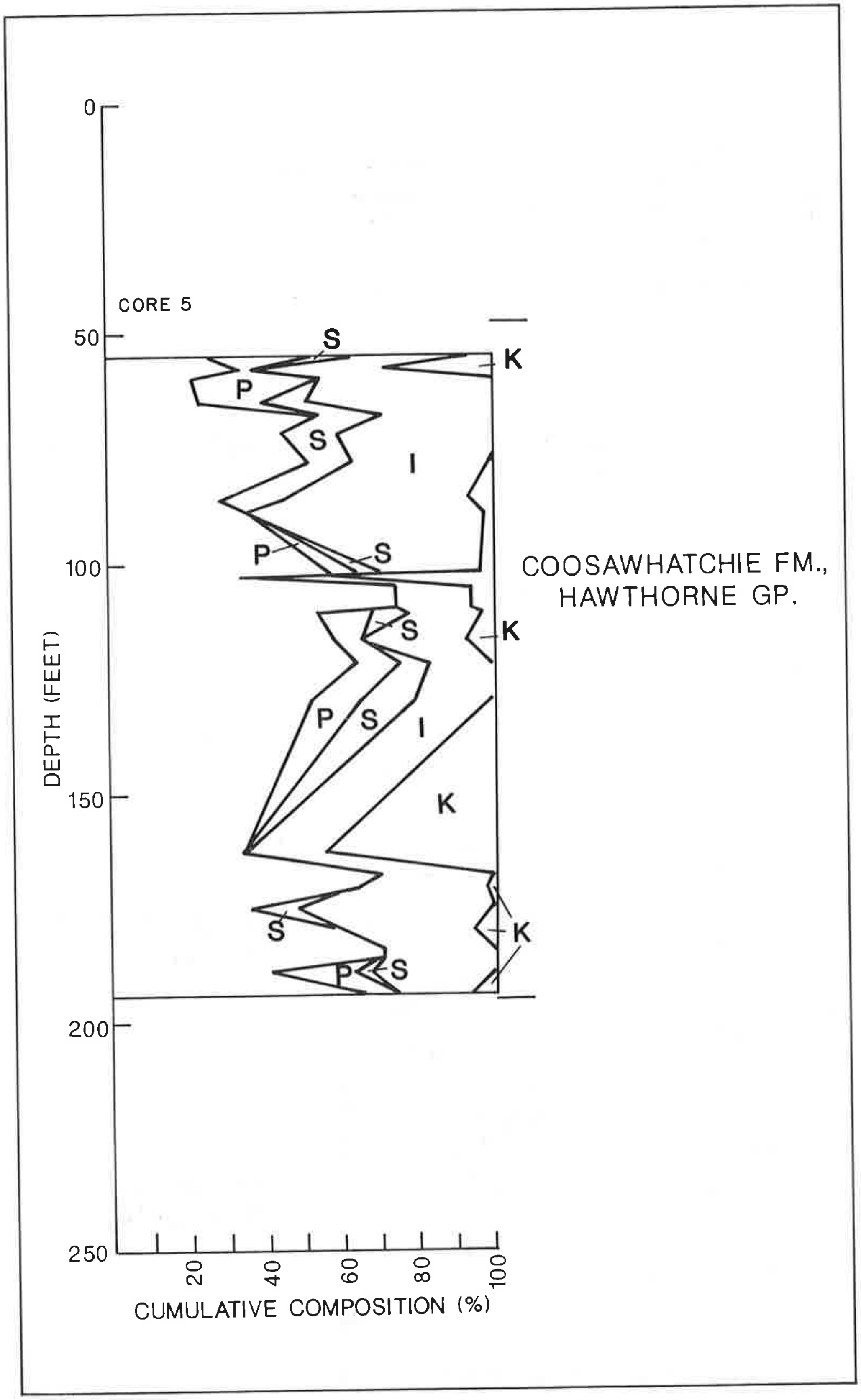

Figure 7. Clay Minerals Distribution in Core 5 (GGS 1339, Camden 2).
K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

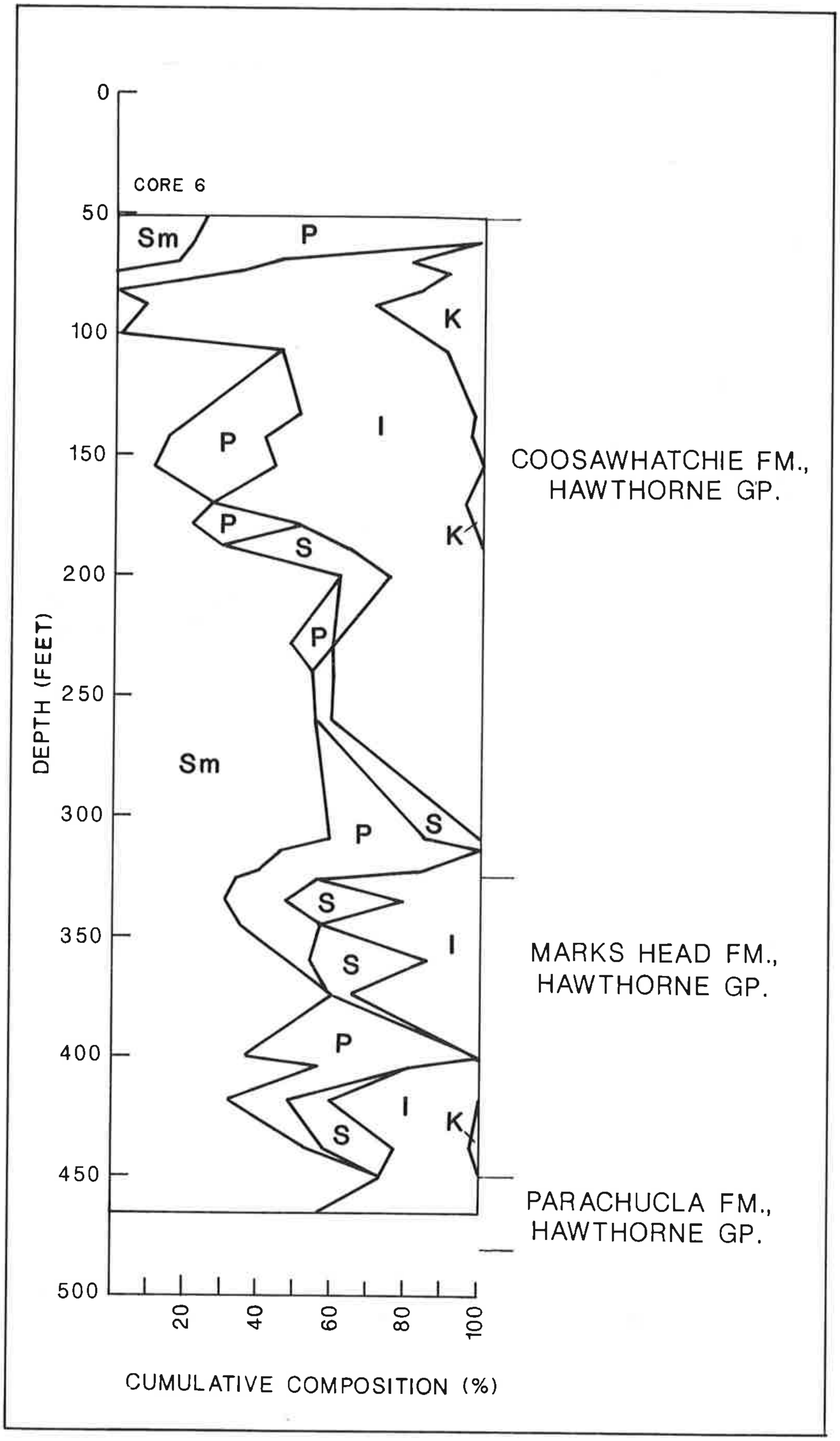

Figure 8. Clay Minerals Distribution in Core 6 (GGS 3185, Charlton 2).
K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

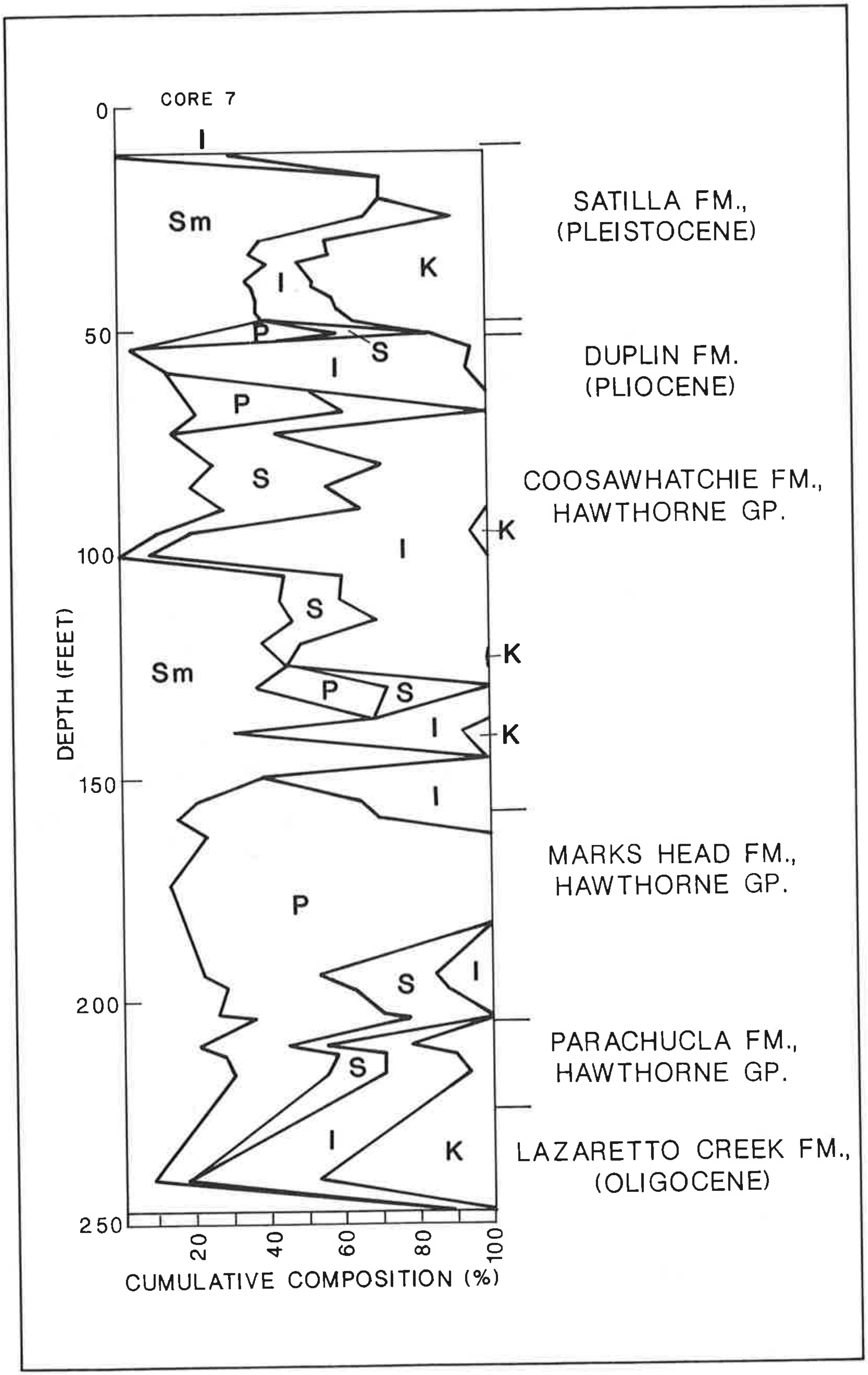

Figure 9. Clay Minerals Distribution in Core 7 (GGS 535, Chatham 1).
K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

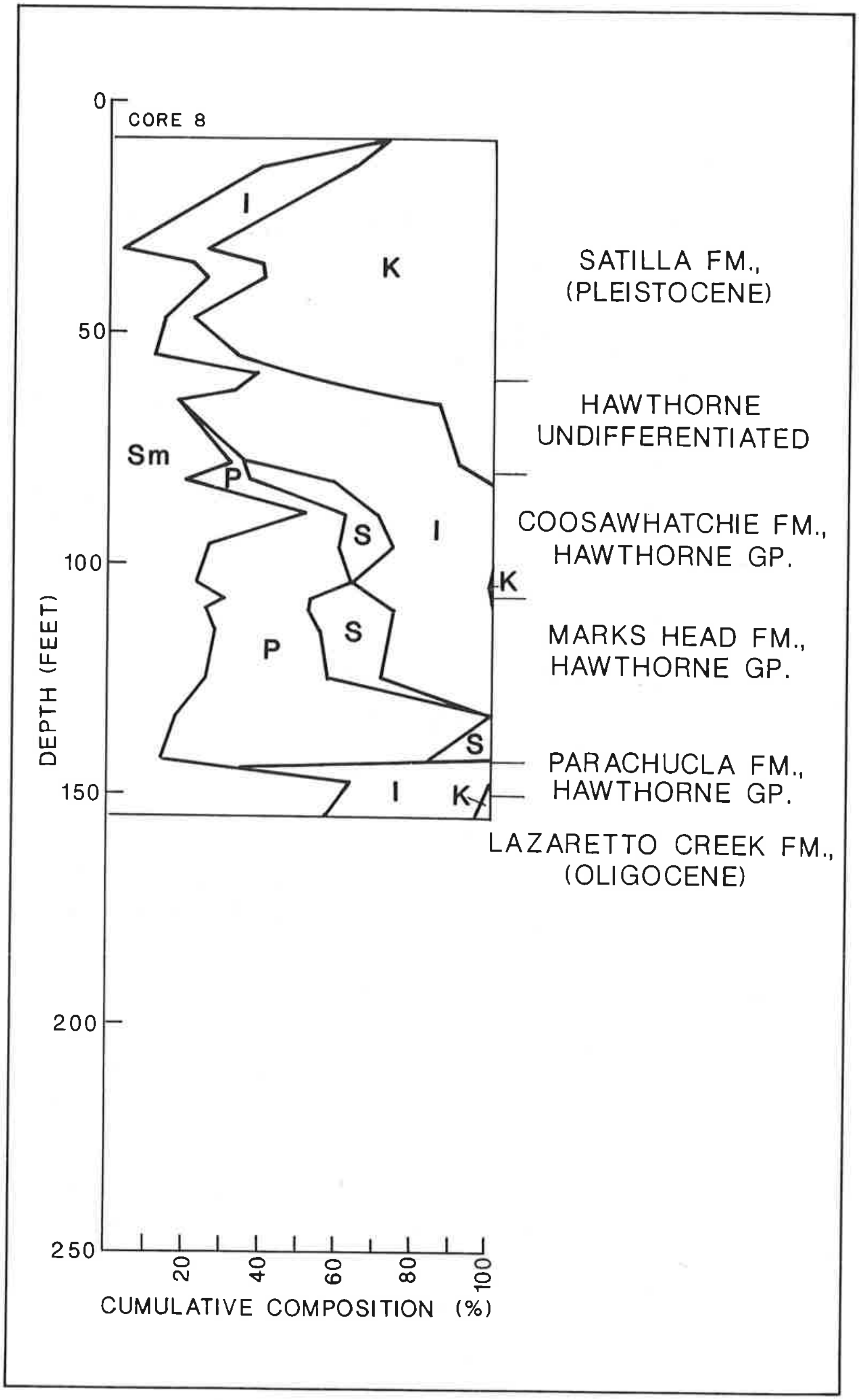

Figure 10. Clay Minerals Distribution in Core 8 (GGS 1341, Chatham 3). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

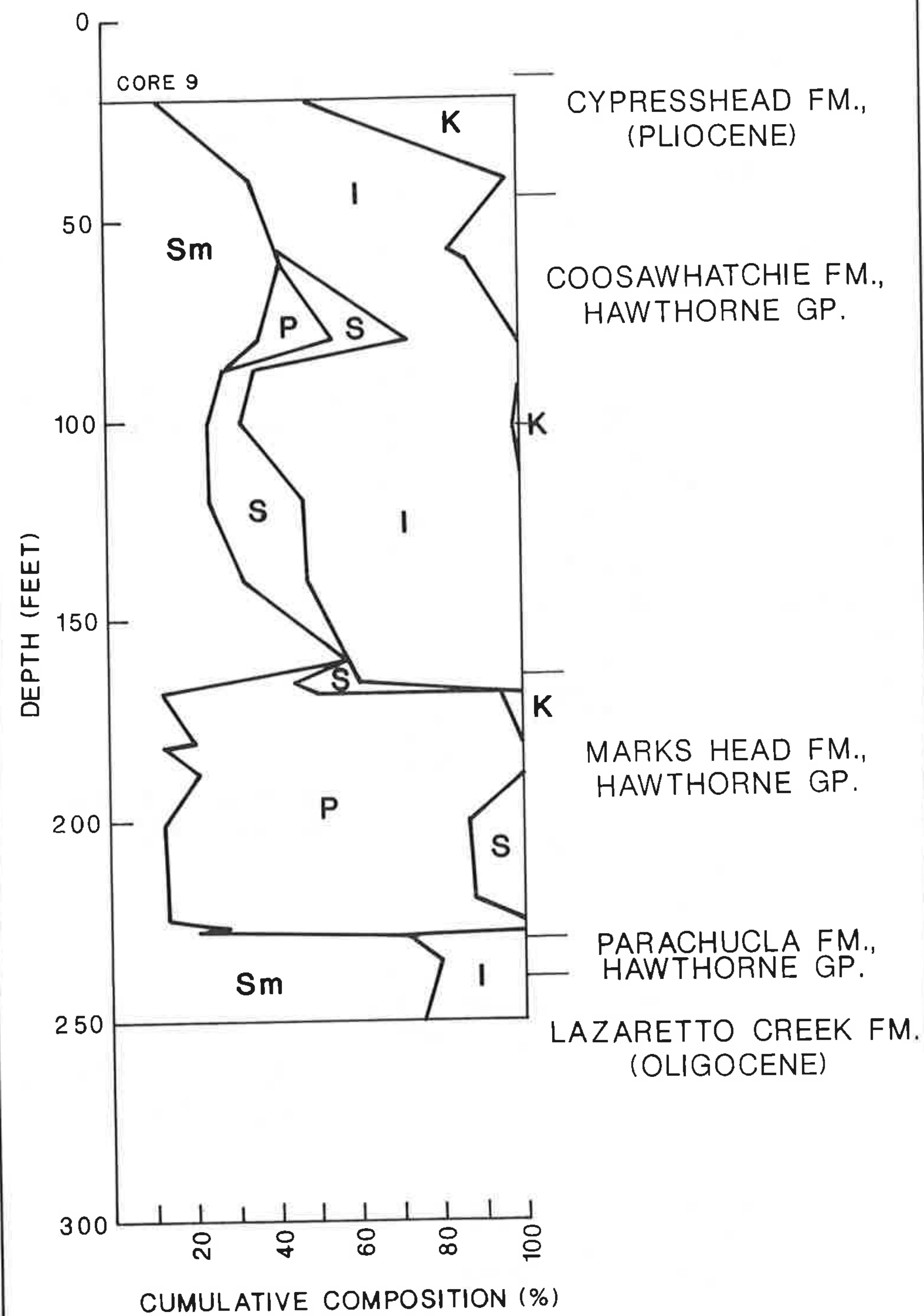

Figure 11. Clay Minerals Distribution in Core 9 (GGS 3139, Chatham 14). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

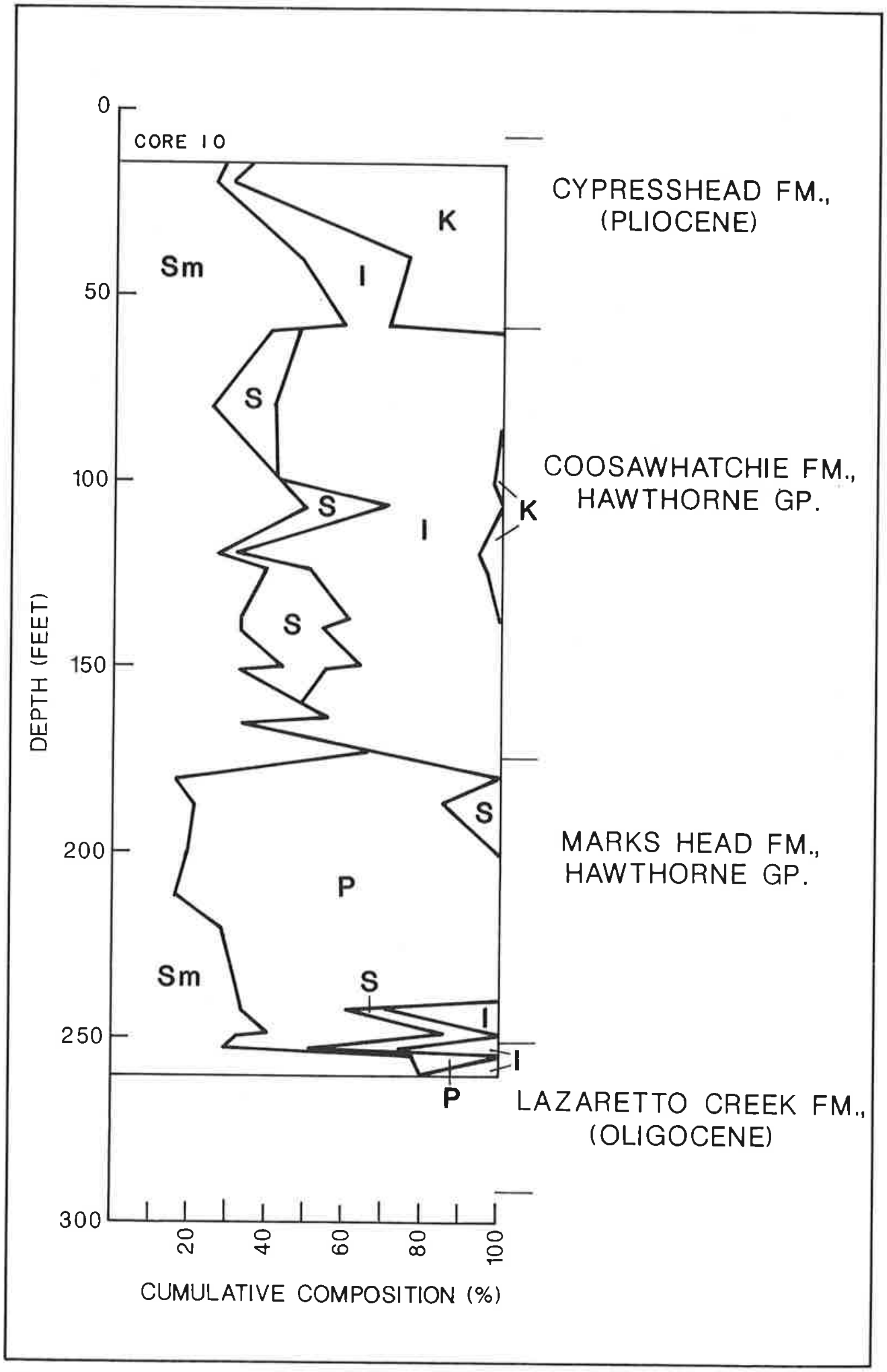

Figure 12. Clay Minerals Distribution in Core 10 (GGS 3135, Chatham 15). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

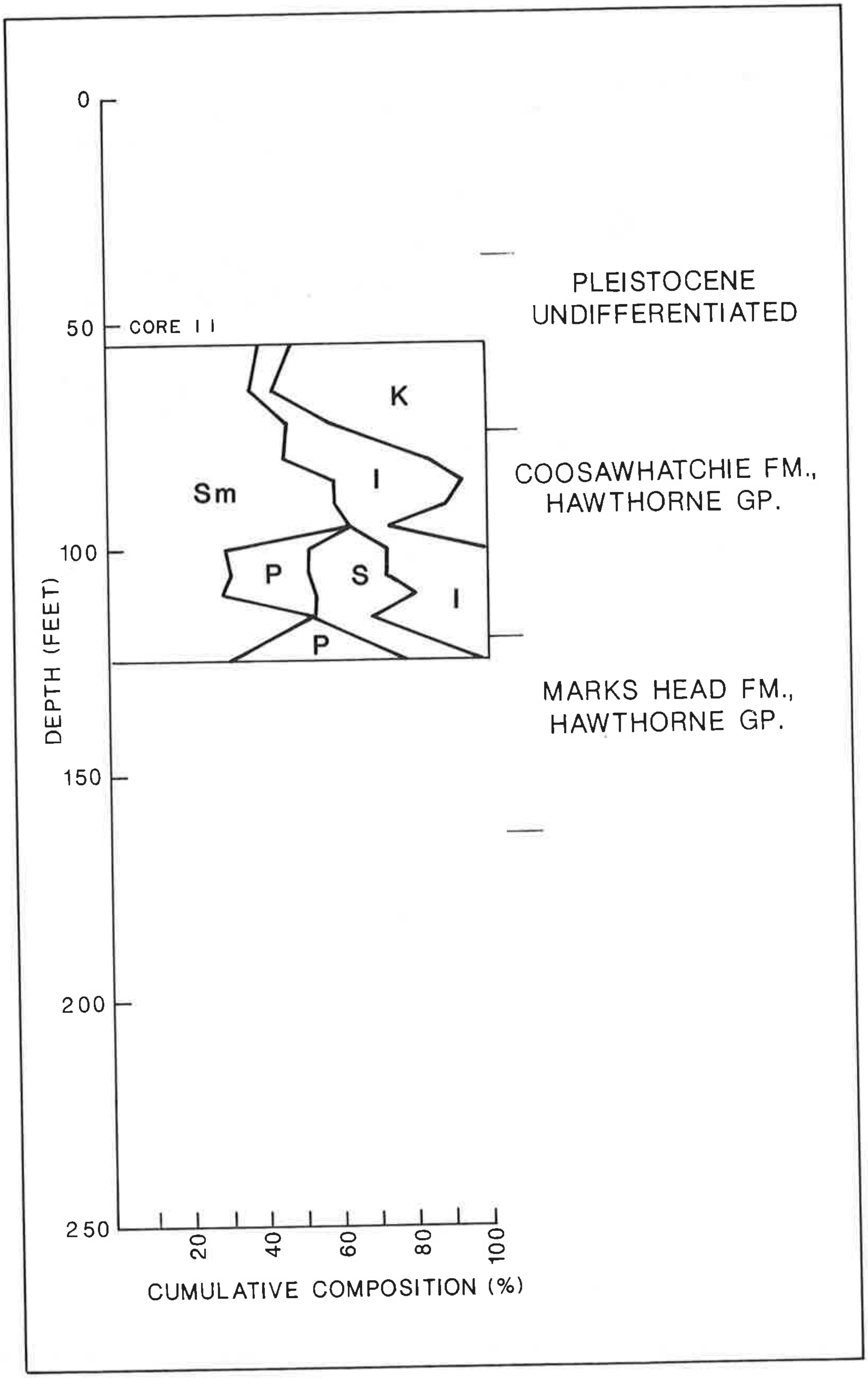

Figure 13. Clay Minerals Distribution in Core 11 (GGS 1445, Chatham 13).
K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

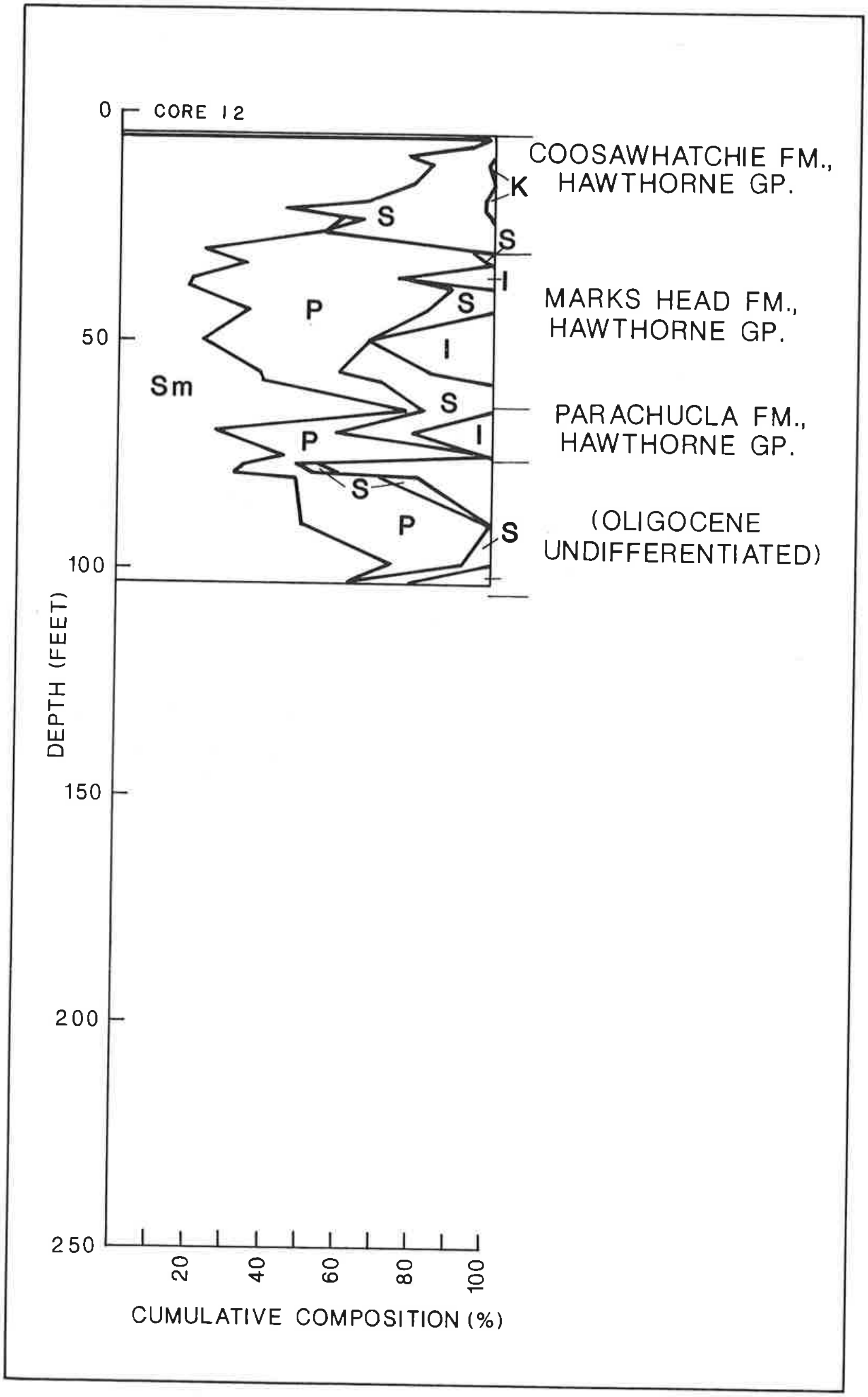

Figure 14. Clay Minerals Distribution in Core 12 (S. Carolina Geologic Survey, Dawson Landing).

K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

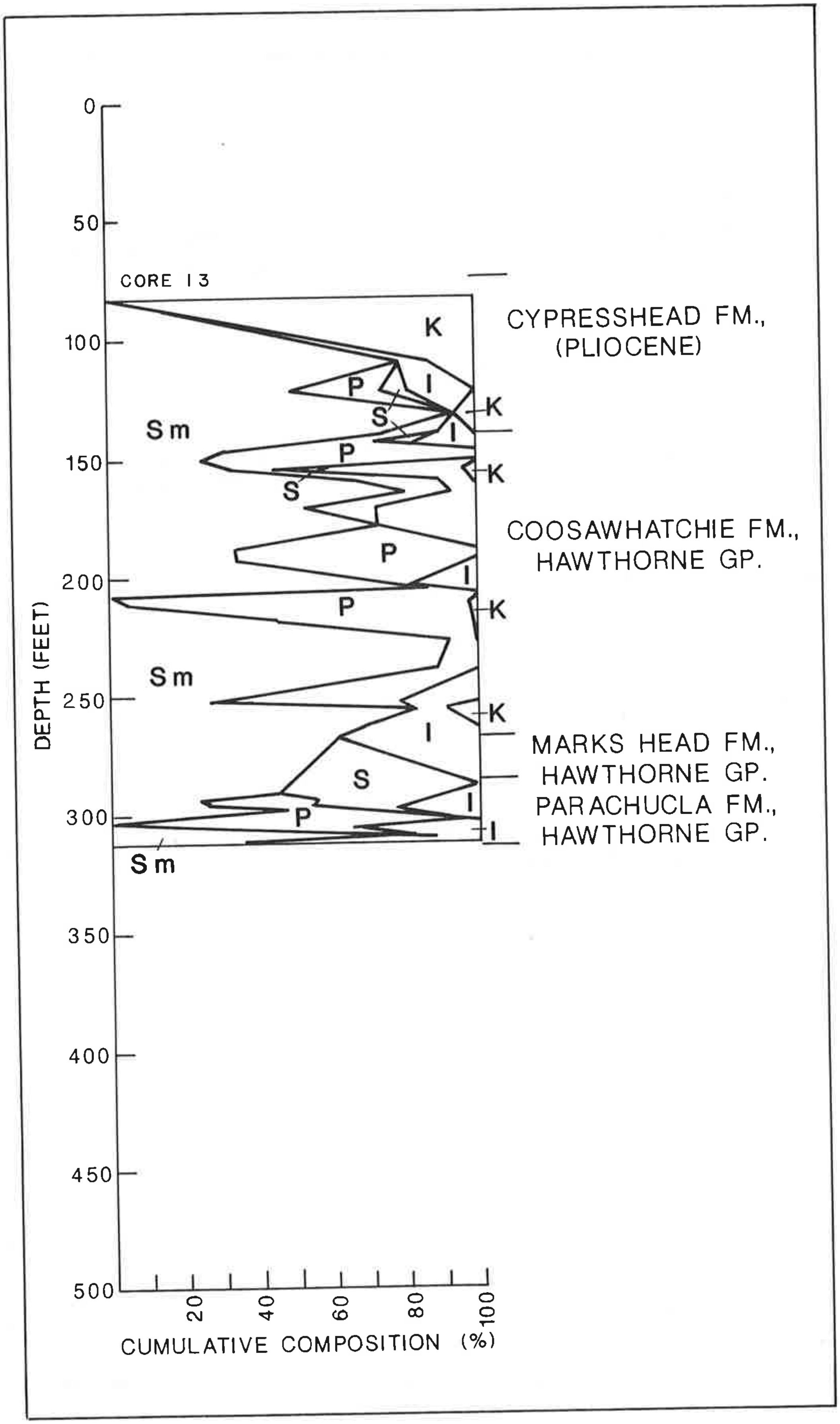

Figure 15. Clay Minerals Distribution in Core 13 (Fla. Bureau of Geology W-10488). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

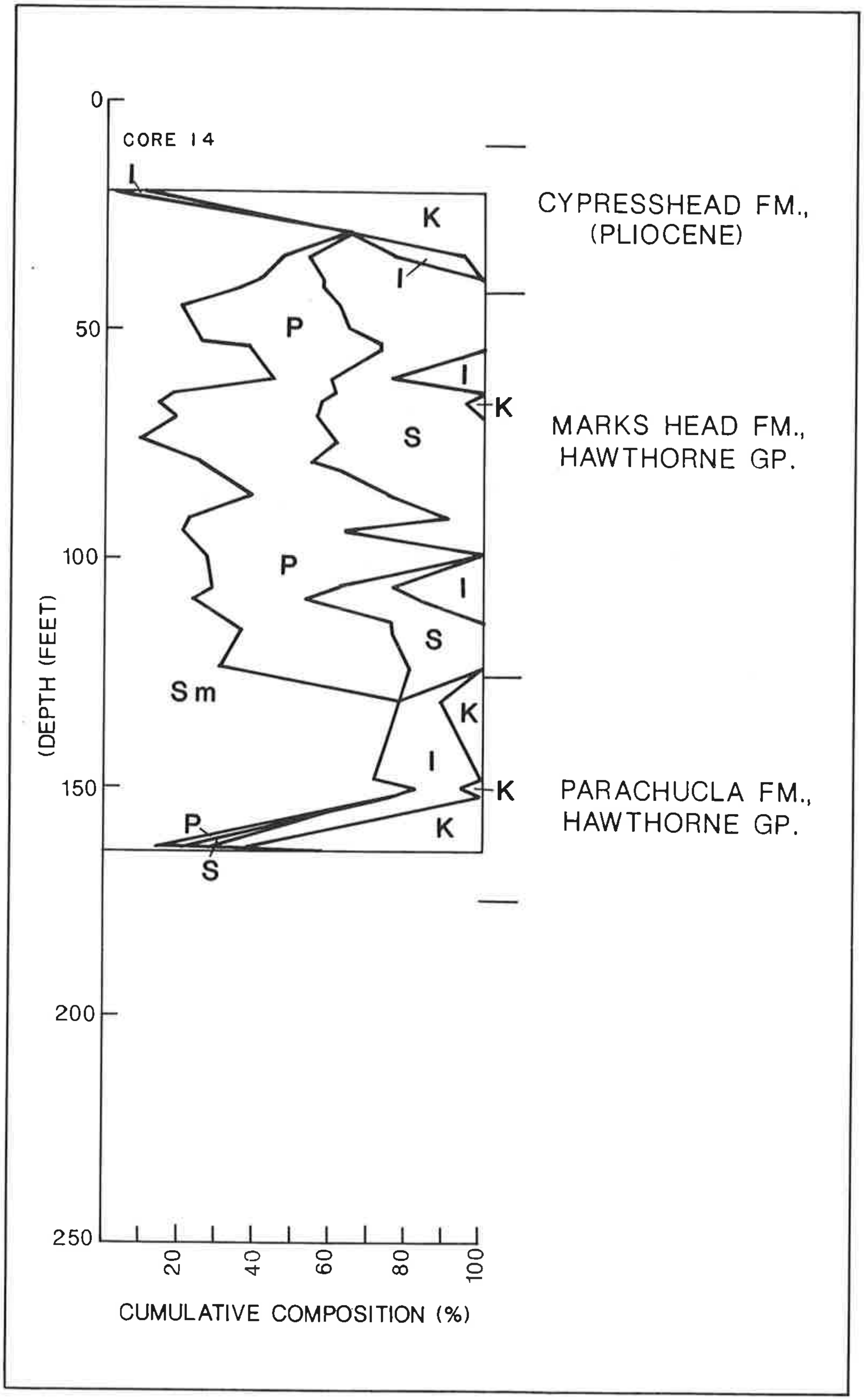

Figure 16. Clay Minerals Distribution in Core 14 (GGS 2179, Effingham 6).
K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

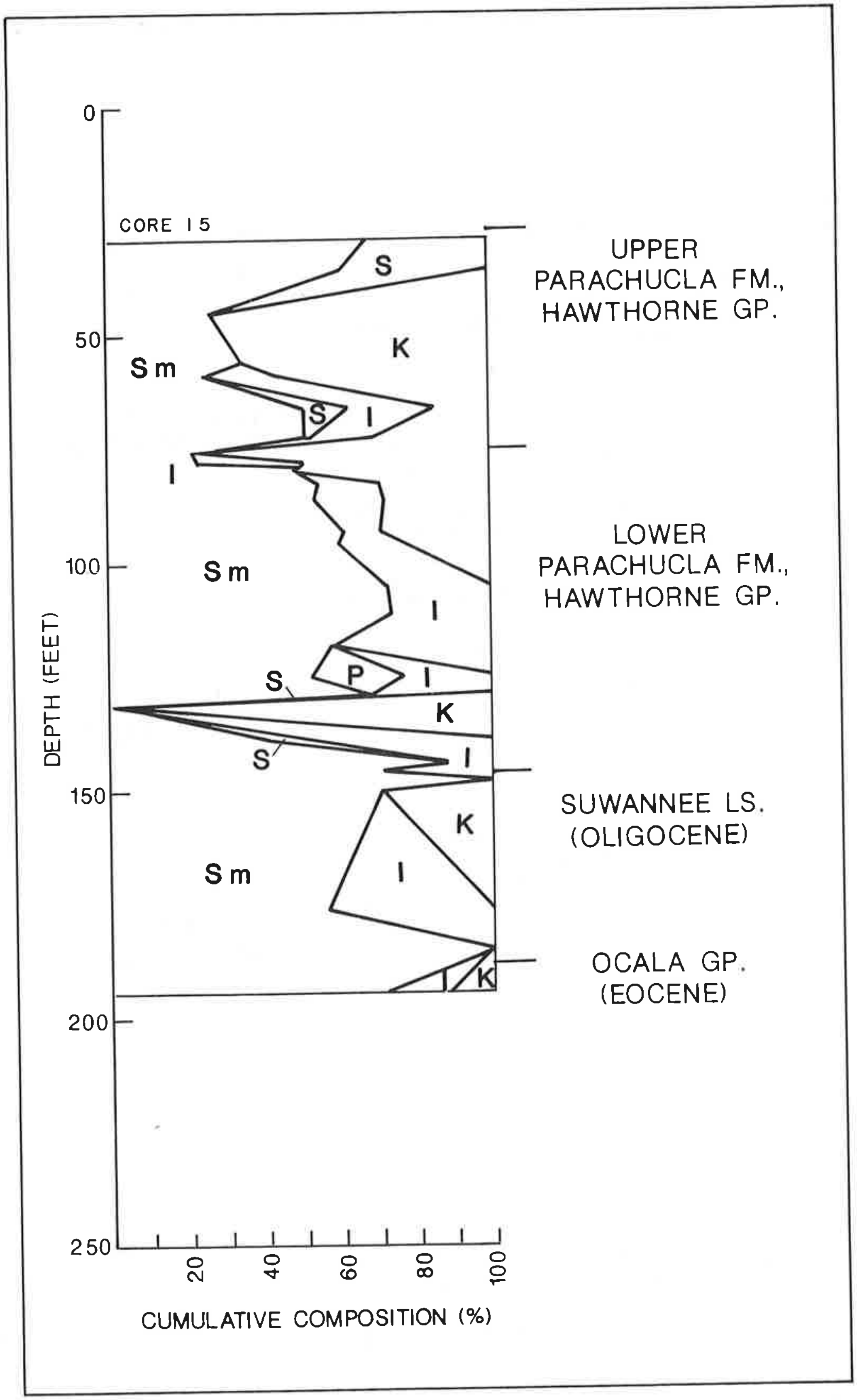

Figure 17. Clay Minerals Distribution in Core 15 (GGS 3108, Effingham 10). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

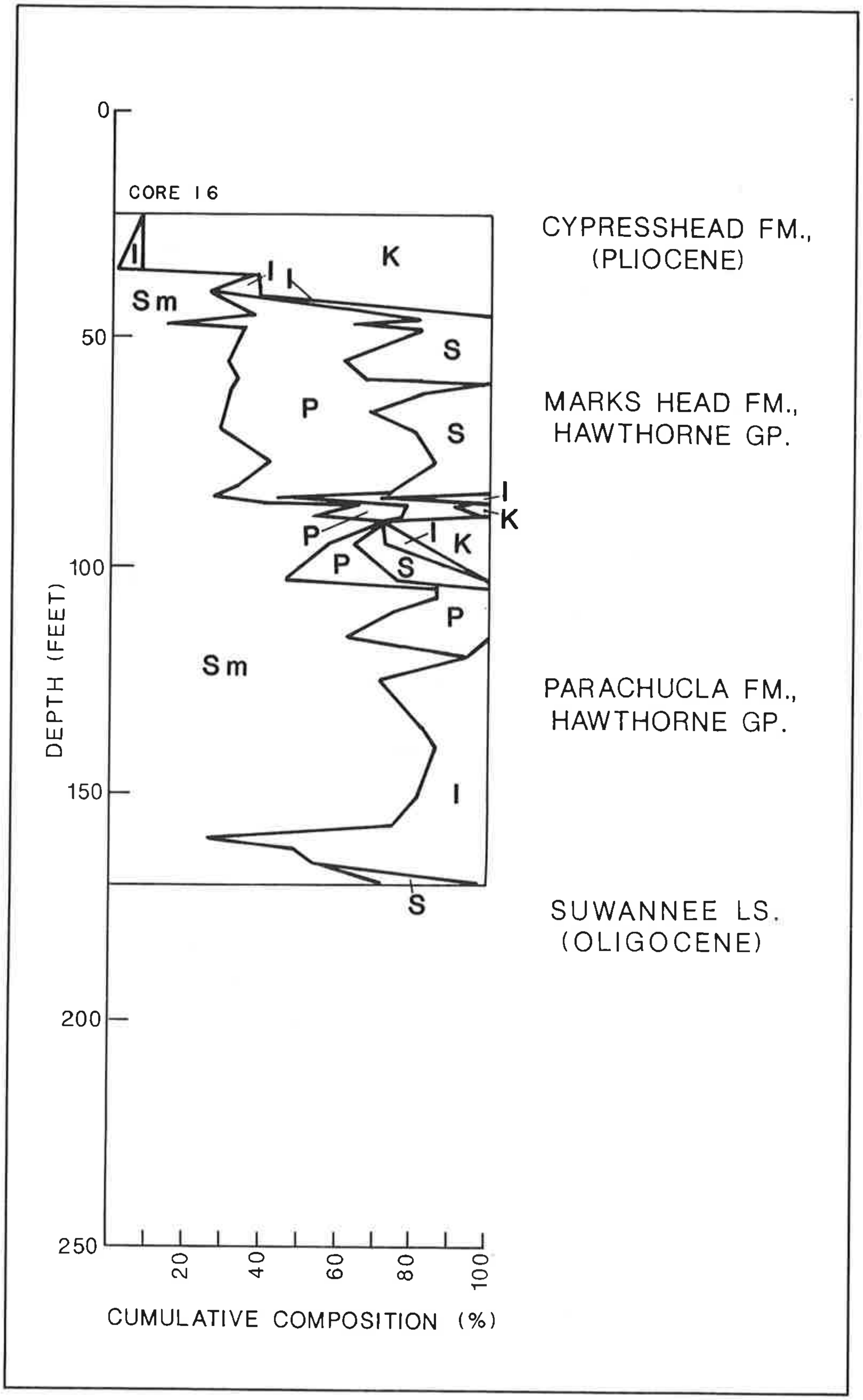

Figure 18. Clay Minerals Distribution in Core 16 (GGS 3109, Effingham 11). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

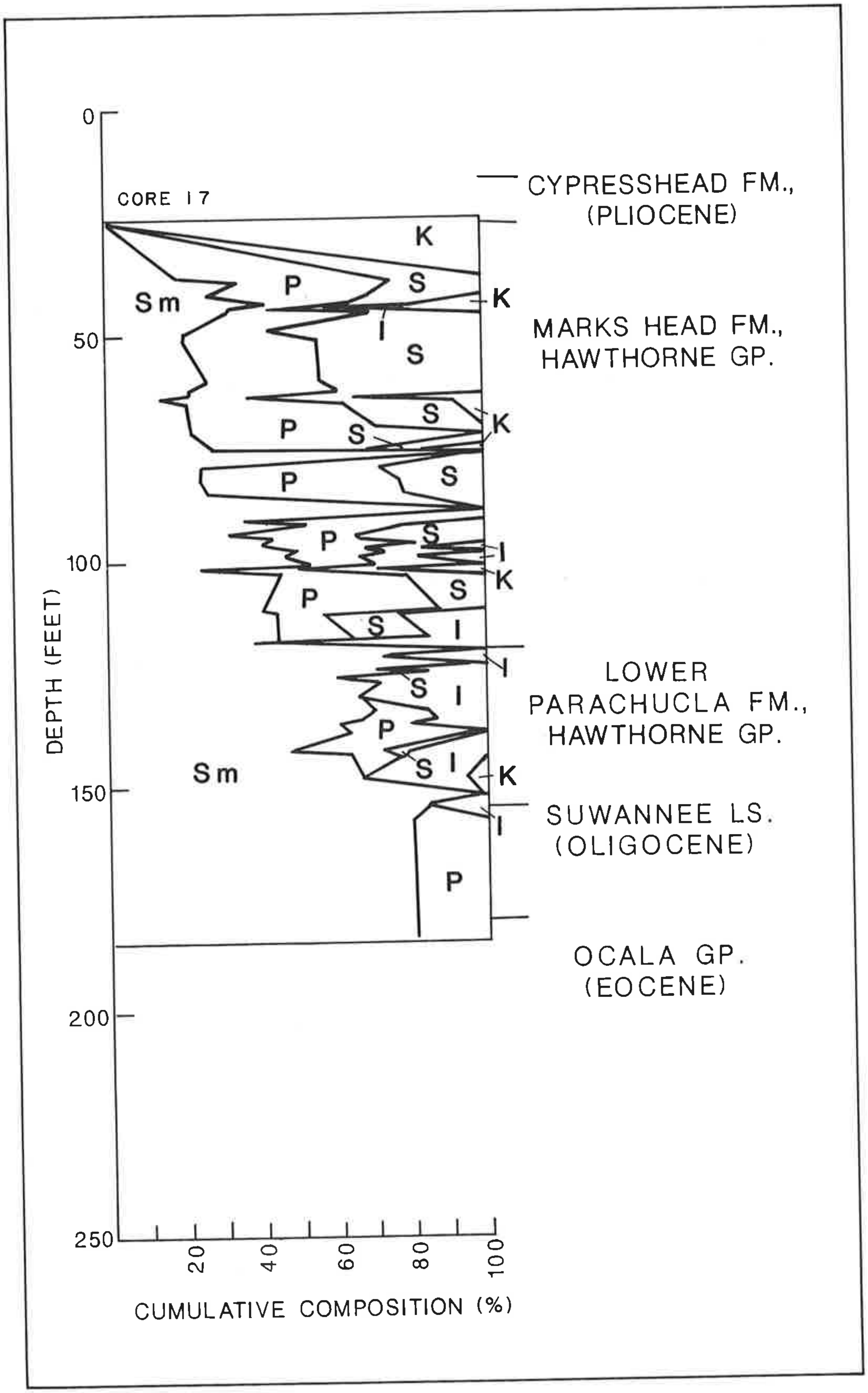

Figure 19. Clay Minerals Distribution in Core 17 (GGS 3110, Effingham 12). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

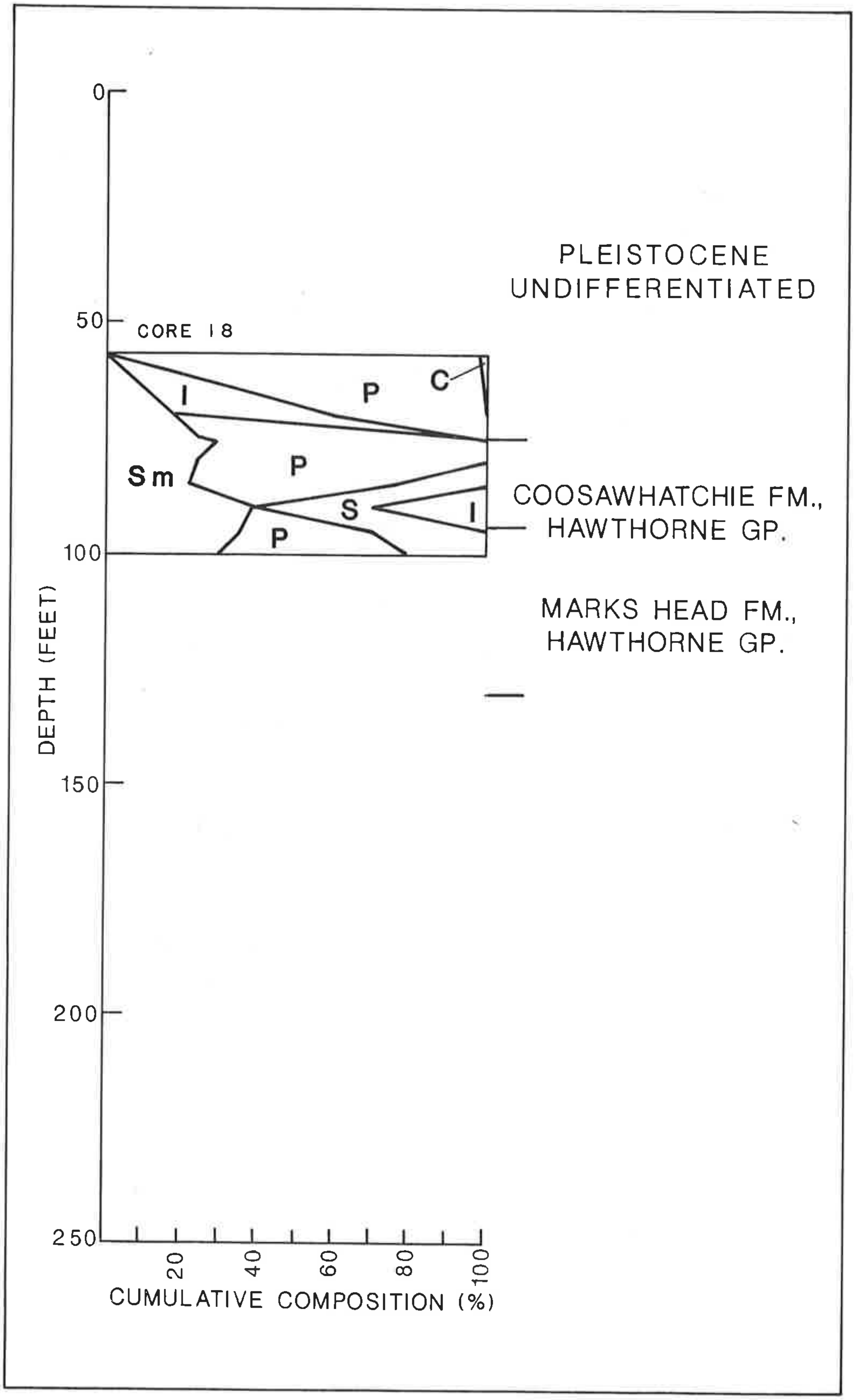

Figure 20. Clay Minerals Distribution in Core 18 (GGS 1394, Chatham 10). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

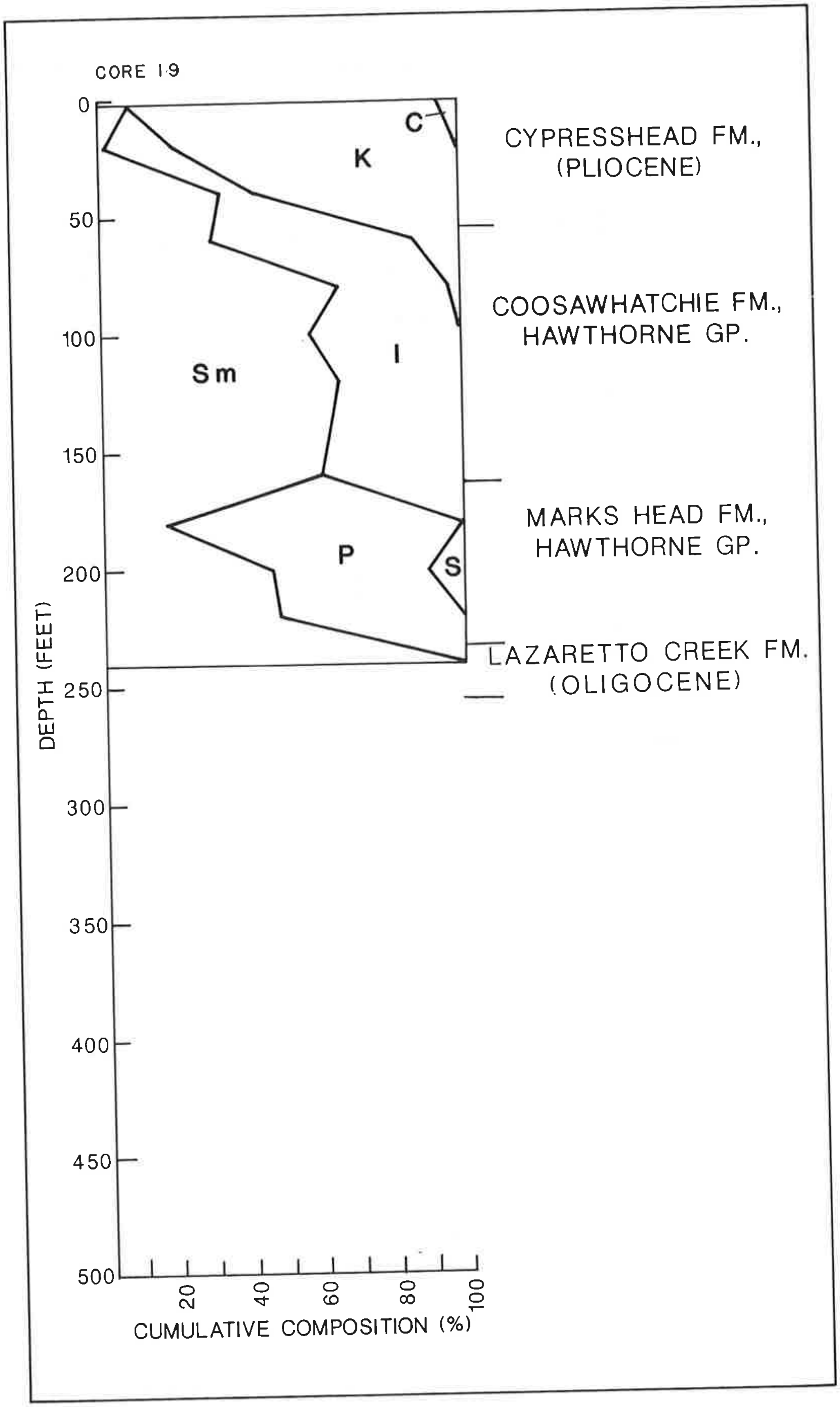

Figure 21. Clay Minerals Distribution in Core 19 (GGS 3155, Effingham 14). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

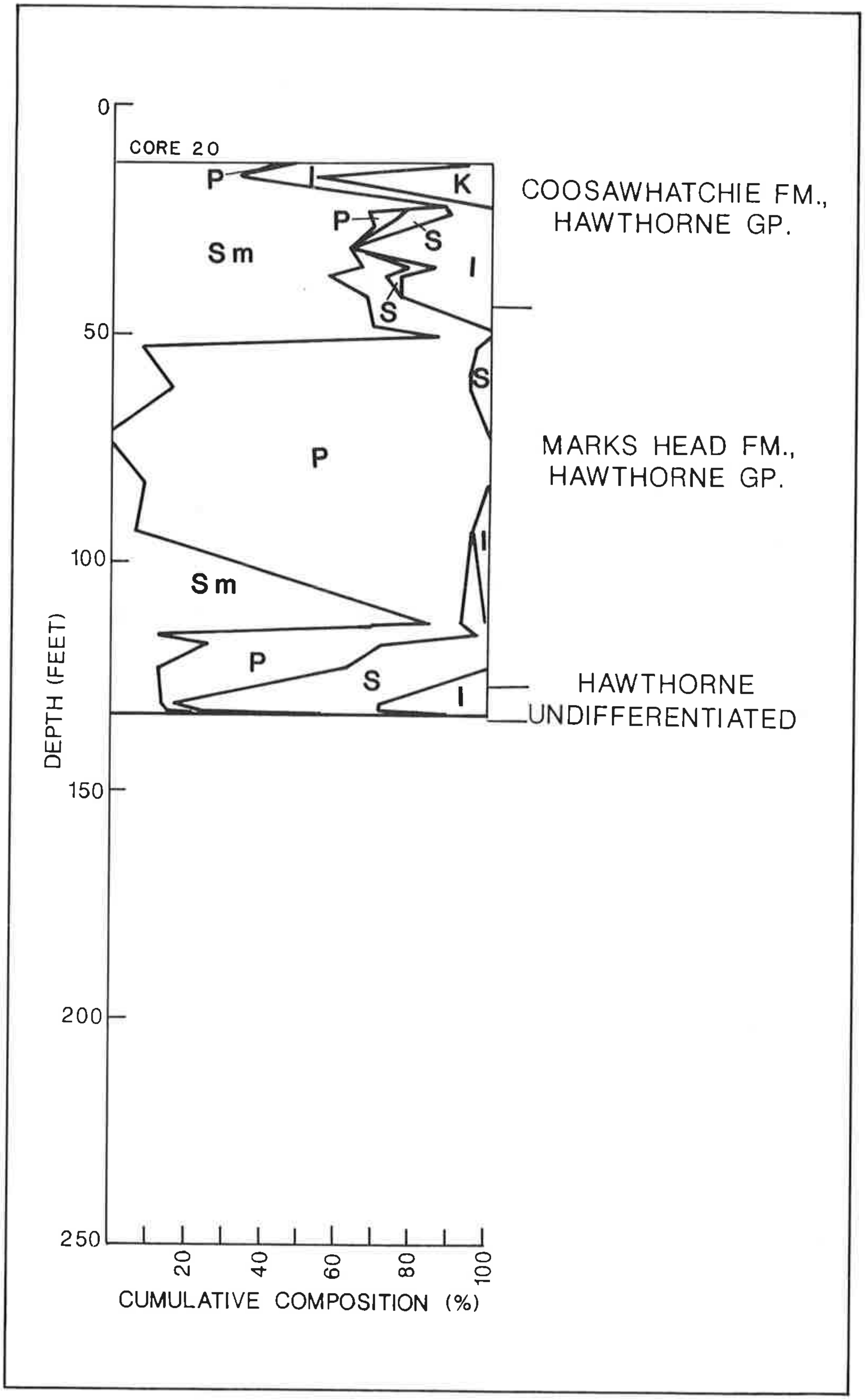

Figure 22. Clay Minerals Distribution in Core 20 (Fla. Bureau of Geology W-11486). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

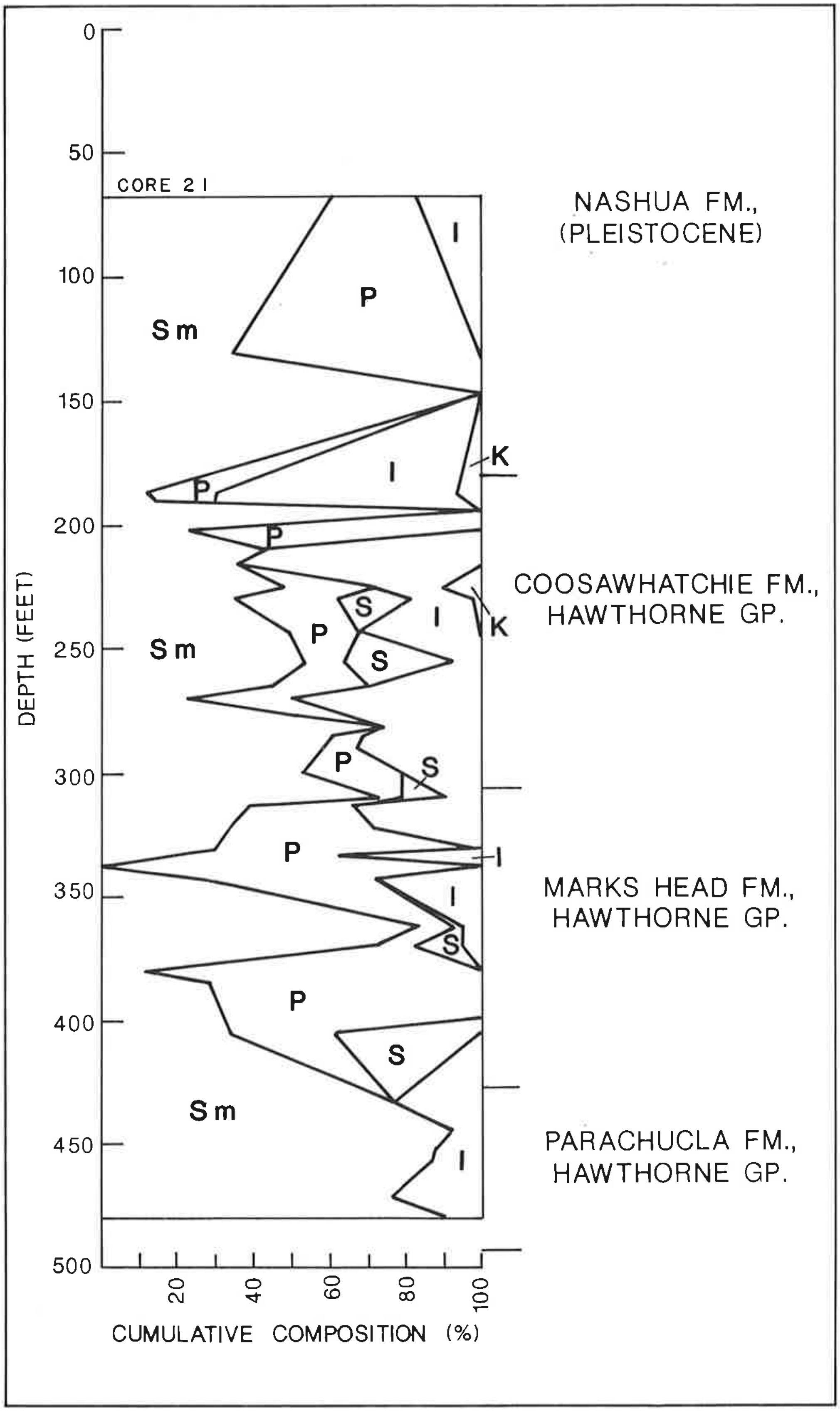

Figure 23. Clay Minerals Distribution in Core 21 (Fla. Bureau of Geology W-12360). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

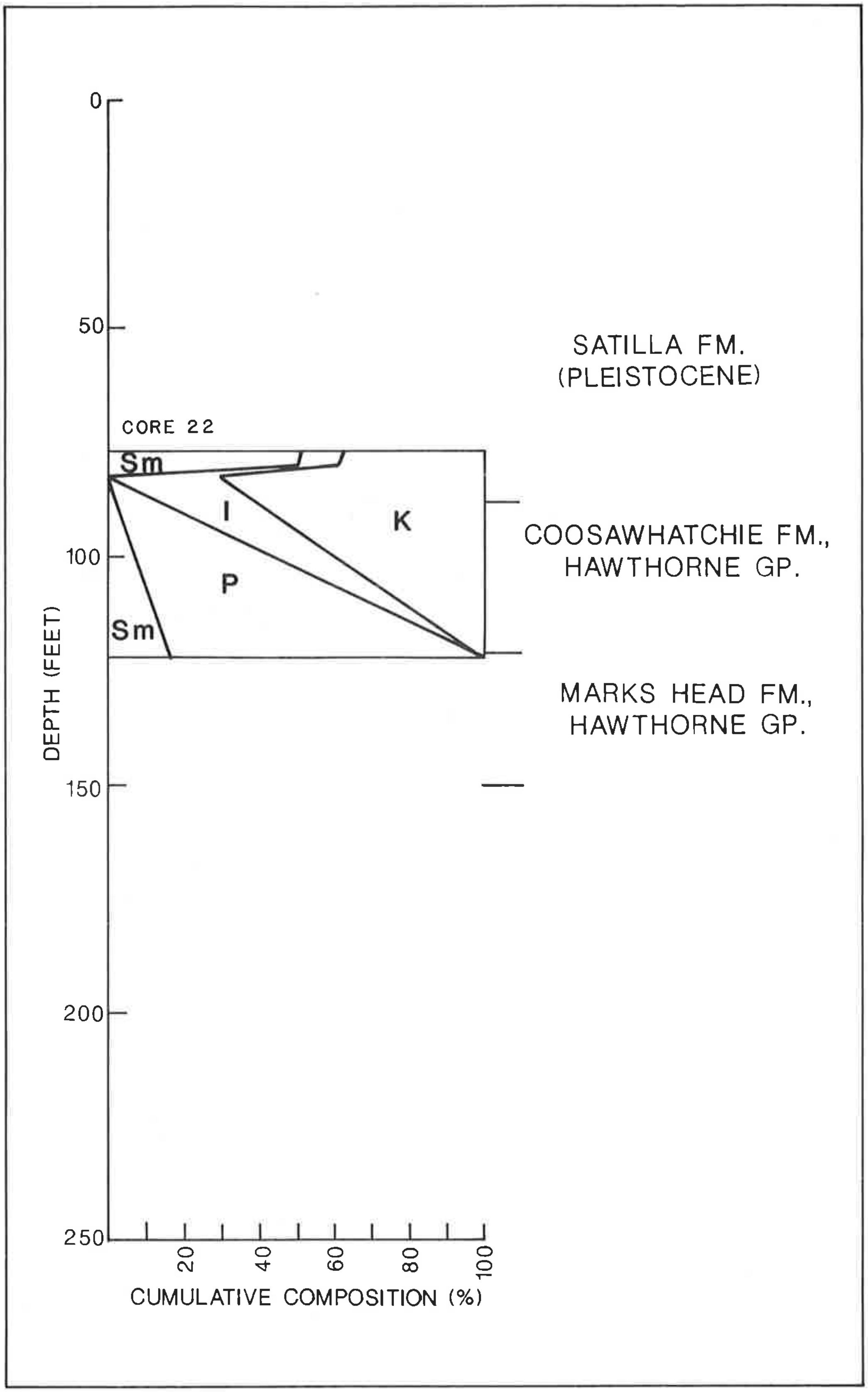

Figure 24. Clay Minerals Distribution in Core 22 (GGS 1164, Petit Chou). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

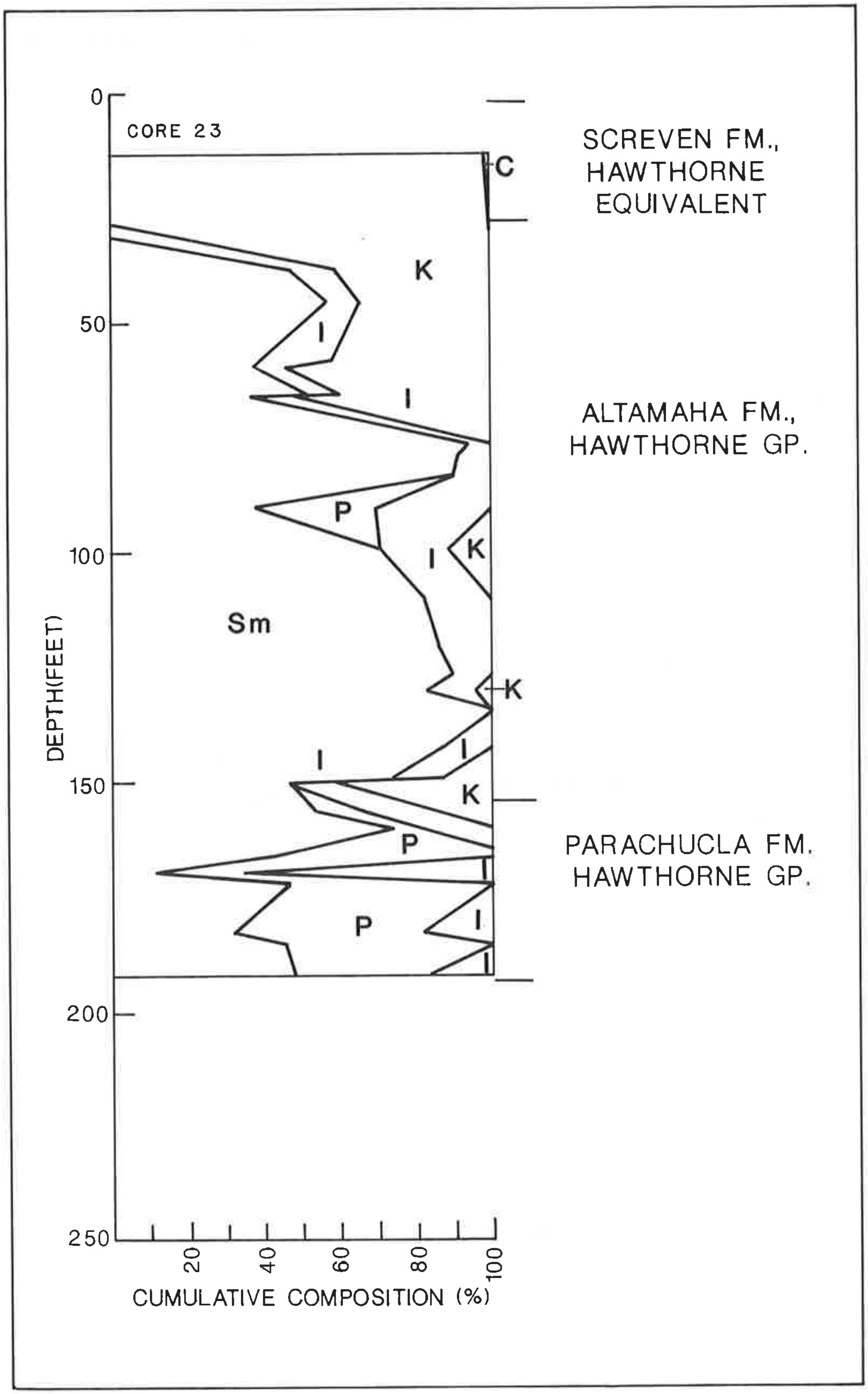

Figure 25. Clay Minerals Distribution in Core 23 (GGS 3198. Screven 8). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

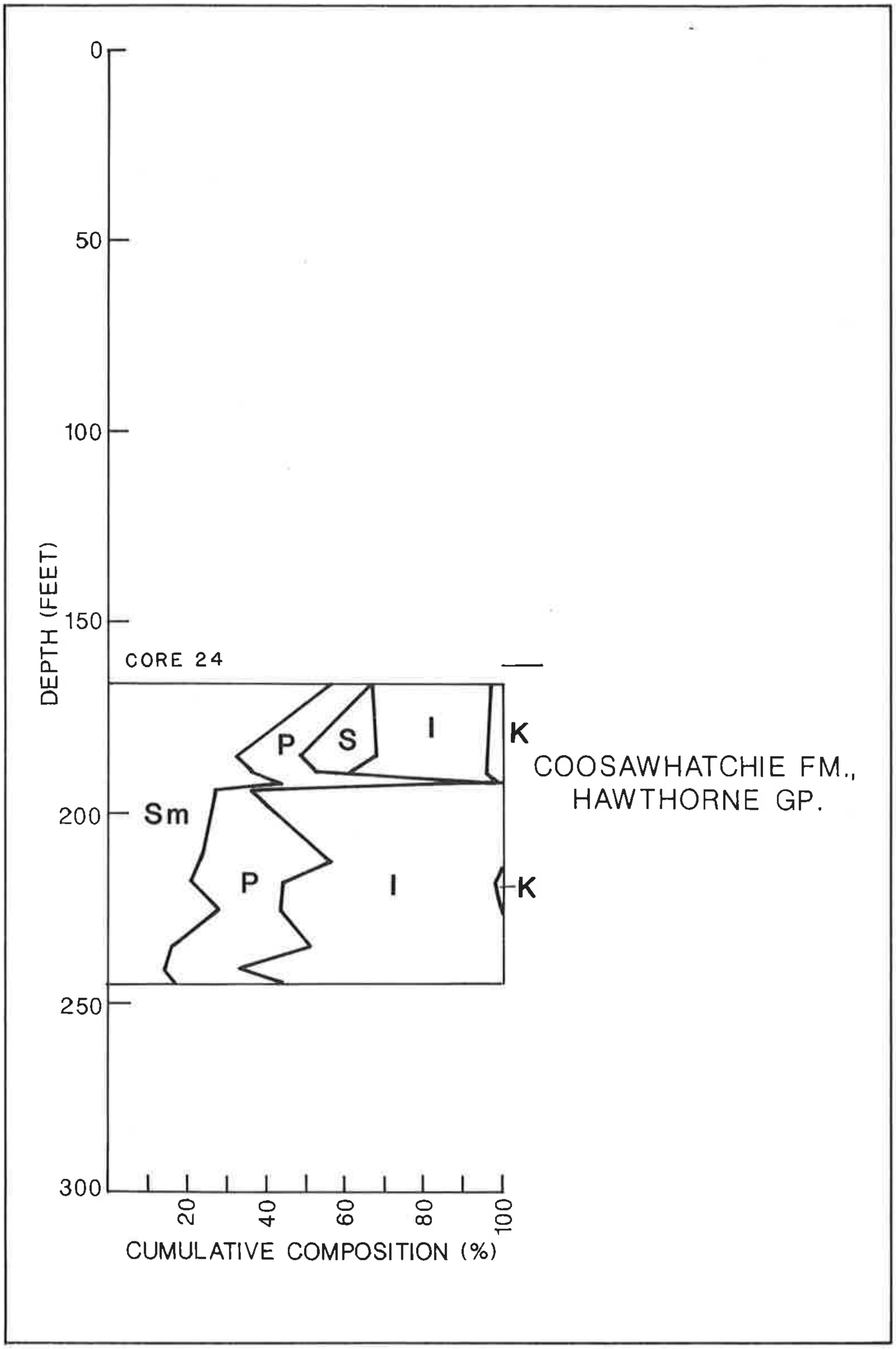

Figure 26. Clay Minerals Distribution in Core 24 (Fla. Bureau of Geology W-10473). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

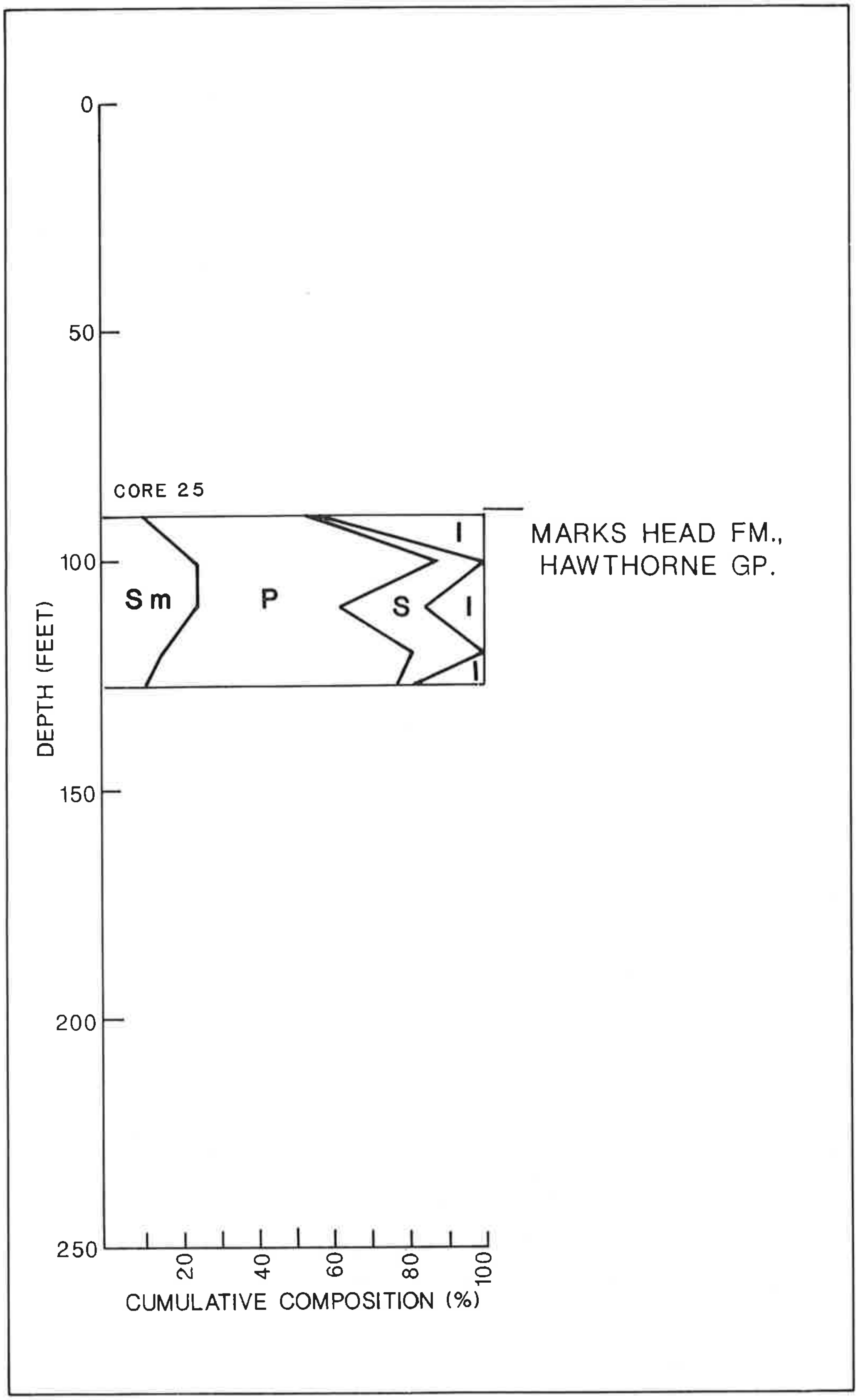

Figure 27. Clay Minerals Distribution in Core 25 (U.S.G.S., Chatham 484). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

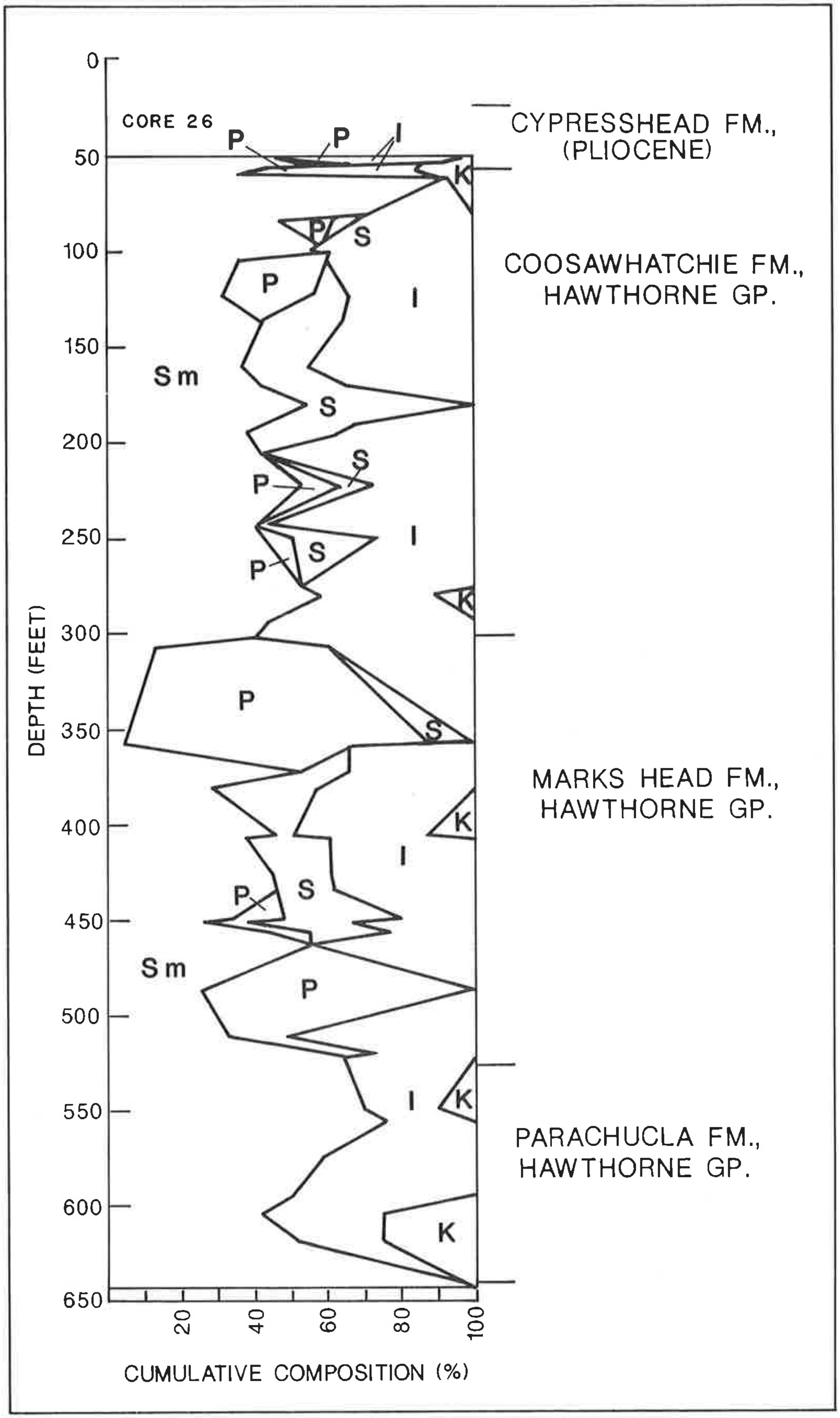

Figure 28. Clay Minerals Distribution in Core 26 (GGS 3512, Wayne 2). K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

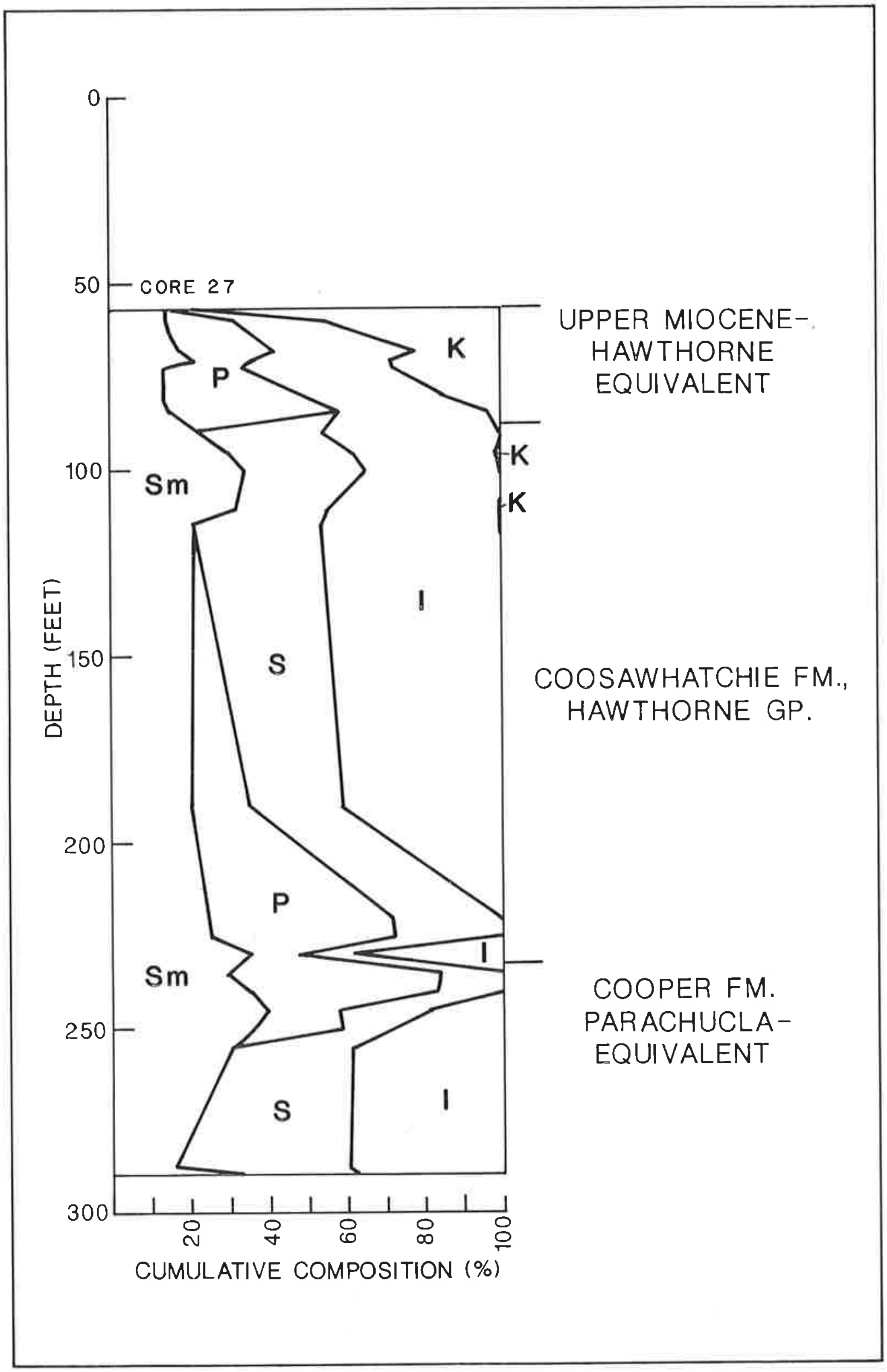

Figure 29. Clay Minerals Disbribution in Core 27 (U.S.G.S. 6002).
K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

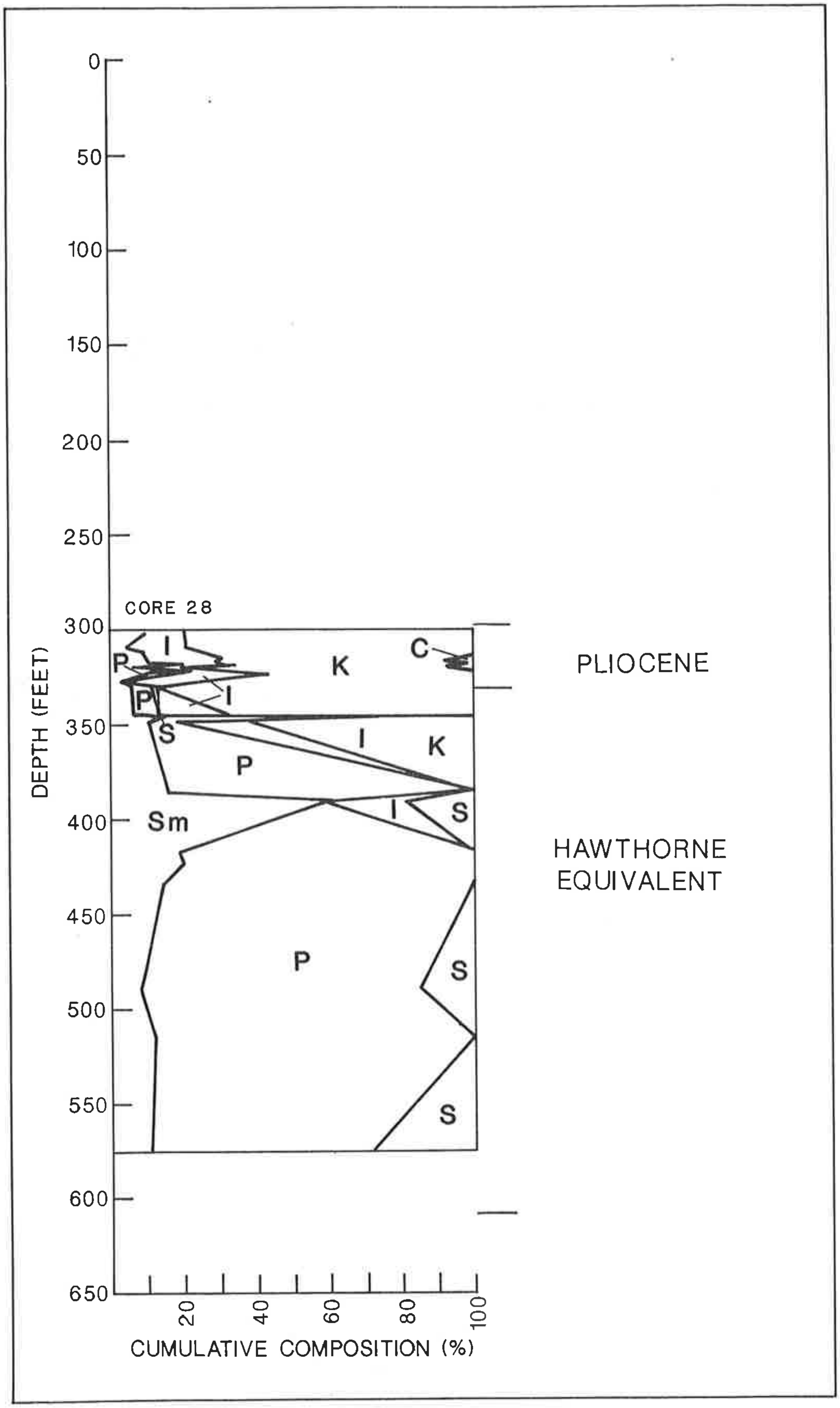

Figure 30. Clay Minerals Distribution in Core 28 (U.S.G.S. 6004).
K-kaolinite, I-illite, S-sepiolite, P-palygorskite, Sm-smectite, C-Chlorite

of samples, and variables tested (minerals) are given in Table 2. Similar information is given in Table 3 for geologic units for which less than 20 samples were available.

In order to determine if there are significant differences between the geologic units with respect to the clay mineral composition, a Kruskal-Wallis one-way analysis of variance of ranks (Siegel, 1956, p. 184-194) was performed for each clay mineral. This is a nonparametric test and it was used because a preliminary examination found that the data are not normally distributed. In each of the Kruskal-Wallis tests, the null hypothesis was that all of the measurements for each variable came from a single population. That is, with respect to the clay mineral under consideration, there is no significant difference between the different geologic units.

Each clay mineral was tested by a separate Kruskal-Wallis analysis. For each clay mineral the compositional data from all of the geologic units were ranked by ascending numerical value. The individual values were assigned ranks, with the smallest value having a rank of 1, the next smallest a rank of 2, and so on for each value. The resulting ranks are approximately normally distributed (Dixon and Massey, 1969, p. 344). The Kruskal-Wallis statistic $H = 12/(N(N+1)) \Sigma R^2{}_i/n_i - 3(N + 1)$ (Siegel, 1956) was used. In the above equation N is the total number of observations (690), R_i is the sum of the ranks for geologic unit i and n_i is the number of observations for geologic unit i. For each clay mineral, the above equation was used to test the hypothesis that there are no significant differences in clay mineral composition among the seven geologic units evaluated. The H statistic calculated for each mineral is given in Table 4 along with the critical X^2 value. If the H statistic exceeds the X^2 value the null hypothesis of equality of the geologic units is rejected.

TABLE 4. RESULTS OF KRUSKAL-WALLIS ANALYSIS OF VARIANCE

Critical $X^2_{.95,6}$	H*	Mineral
	128.3	Smectite
12.6	119.6	Palygorskite
	90.6	Sepiolite
	150.3	Illite
	147.0	Kaolinite

*The statistic calculated which follows a X^2 distribution

The null hypothesis was tested and rejected for each of the clay minerals at the 0.95 probability level. The Kruskal-Wallis test, however, does not provide information as to which geologic units (or unit) are significantly different in clay mineral composition; it only proves that one or more are not equal. In order to determine which geologic units (or unit) were different in clay mineral composition, it was necessary to use a parametric statistical method that is normally used in analysis of variance as a second step. The method used was Scheffe's method (Guenther, 1964, p. 57) for multiple comparisons (hereafter referred to as the S-method). According to Guenther (1964, p. 58) "An additional advantage associated with this method (S-method) is that it is known to be affected very little if the assumptions of normality and equal variances are not satisfied." For example, the S-method can examine orthogonal contrasts such as $\mu_{7p} - \mu_{6p} = 0$ where μ_{7p} is the mean p (palygorskite) composition of formation 7 (Marks Head) and μ_{6p} is the mean p (palygorskite) composition of formation 6 (Coosawhatchie). The above equation is a mathematical expression of the hypothesis that the mean palygorskite contents of the Marks Head and Coosawhatchie Formations are equal. For a lucid discussion of the equations and statistical methods used in testing such orthogonal contrasts, the reader is directed to Guenter (1964, pp. 50-59).

The S-method test yields two numbers, the upper limit and the lower limit of a confidence interval. If the numerical range defined by these limits includes zero, the data passes the S-method test and the means are not statistically different. The results of S-method tests on the selected hypotheses are significant at the 0.95 confidence level and are given in Table 5.

TABLE 5

RESULTS OF SCHEFFE' METHOD TESTS

Geologic Units Tested for Equal Mineral Composition Means	Orthogonal Contrast Tested*	Lower Limit	Upper Limit	Result
Pleistocene and Pliocene Compared to Marine Hawthorne Group	$\mu_{2m} + \mu_{3m} + \mu_{9m} - \mu_{6m} - \mu_{7m} - \mu_{8m} = 0$	-22.7	29.7	Not Significant
	$\mu_{2p} + \mu_{3p} + \mu_{9p} - \mu_{6p} - \mu_{7p} - \mu_{8p} = 0$	-75.6	-22.1	Rejected
	$\mu_{2s} + \mu_{3s} + \mu_{9s} - \mu_{6s} - \mu_{7s} - \mu_{8s} = 0$	-35.1	-5.7	Rejected
	$\mu_{2i} + \mu_{3i} + \mu_{9i} - \mu_{6i} - \mu_{7i} - \mu_{8i} = 0$	-39.8	3.1	Not Significant
	$\mu_{2k} + \mu_{3k} + \mu_{9k} - \mu_{6k} - \mu_{7k} - \mu_{8k} = 0$	64.2	103.0	Rejected
Marginal Marine - Nonmarine Hawthorne Group Compared to the Marine Hawthorne Group	$\mu_{11m} + \mu_{11m} + \mu_{11m} - \mu_{6m} - \mu_{7m} - \mu_{8m} = 0$	26.4	87.6	Rejected
	$\mu_{11p} + \mu_{11p} + \mu_{11p} - \mu_{6p} - \mu_{7p} - \mu_{8p} = 0$	-94.7	-32.3	Rejected
	$\mu_{11s} + \mu_{11s} + \mu_{11s} - \mu_{6s} - \mu_{7s} - \mu_{8s} = 0$	-45.9	-11.5	Rejected
	$\mu_{11i} + \mu_{11i} + \mu_{11i} - \mu_{6i} - \mu_{7i} - \mu_{8i} = 0$	-50.9	- 0.7	Rejected
	$\mu_{11k} + \mu_{11k} + \mu_{11k} - \mu_{6k} - \mu_{7k} - \mu_{8k} = 0$	38.3	43.0	Rejected

*Numbers in prefix are formation identification numbers (see table 1). Letters in prefixes designate clay minerals where; m = smectite, p = palygorskite, s = sepiolite, i = illite, k = kaolinite.

TABLE 5 (Cont'd)

Geologic Units Tested for Equal Mineral Composition Means	Orthogonal Contrast Tested*	Lower Limit	Upper Limit	Result
	$\mu_{7m} + \mu_{7m} - \mu_{6m} - \mu_{8m} = 0$	-46.0	-23.5	Rejected
Marks Head Formation Compared to the Coosawhatchie and Parachucla Formations	$\mu_{7p} + \mu_{7p} - \mu_{6p} - \mu_{8p} = 0$	45.7	68.7	Rejected
	$\mu_{7s} + \mu_{7s} - \mu_{6s} - \mu_{8s} = 0$	8.7	21.3	Rejected
	$\mu_{7i} + \mu_{7i} - \mu_{6i} - \mu_{8i} = 0$	-40.1	-21.6	Rejected
	$\mu_{7k} + \mu_{7k} - \mu_{6k} - \mu_{8k} = 0$	-15.0	1.7	Not Significant
	$\mu_{8m} + \mu_{8m} - \mu_{7m} - \mu_{6m} = 0$	22.8	47.2	Rejected
Parachucla Formation Compared to the Marks Head and Coosawhatchie Formations	$\mu_{8p} + \mu_{8p} - \mu_{7p} - \mu_{6p} = 0$	-44.0	-19.0	Rejected
	$\mu_{8s} + \mu_{8s} - \mu_{7s} - \mu_{6s} = 0$	-15.2	- 1.5	Rejected
	$\mu_{8i} + \mu_{8i} - \mu_{7i} - \mu_{6i} = 0$	-15.3	4.7	Not Significant
	$\mu_{8k} + \mu_{8k} - \mu_{7k} - \mu_{6k} = 0$	1.1	19.2	Rejected

*Numbers in prefix are formation identification numbers (see table 1). Letters in prefixes designate clay minerals where; m = smectite, p = palygorskite, s = sepiolite, i = illite, k = kaolinite.

The differences of means shown in Table 2 (p.9) were tested for statistical significance. The hypothesis of equal clay mineral composition was tested for each of the following comparisons of geologic units.

(1) Marine Hawthorne Group Formations = overlying Pleistocene Formations and underlying Oligocene Formations.

(2) Marginal marine-nonmarine Altamaha Formation = marine Hawthorne Group Formations.

(3) Marks Head Formation = Parachucla and Coosawhatchie Formations.

(4) Parachucla Formation = Marks Head and Coosawhatchie Formations.

Based on these results the following conclusions were made: (1) The marine Hawthorne Group formations are significantly different in palygorskite, sepiolite, illite, and kaolinite contents from the overlying and underlying sediments. (2) The marginal marine-nonmarine Altamaha Formation of the Hawthorne Group is significantly different in smectite, palygorskite, sepiolite, illite, and kaolinite contents from marine Hawthorne Group formations. (3) The marine Hawthorne Group formations (Coosawhatchie, Marks Head, and Parachucla) are significantly different from each other in smectite, palygorskite, and sepiolite contents. (4) The kaolinite content of the Parachucla Formation is significantly different from the kaolinite content of the Coosawhatchie and the Marks Head Formations. (5) The illite content of the Marks Head Formation is significantly different from the illite contents of the Coosawhatchie and the Parachucla Formations.

CONCLUSIONS

The two primary conclusions of the study are: (1) the marine portion of the Hawthorne Group is unique in its clay mineral composition when compared to associated sediments, and (2) the formations which compose the Hawthorne Group are significantly different from each other in clay mineral composition. These conclusions conform to the conclusions of Weaver and Beck (1977) and support the recent revision of Hawthorne Group stratigraphic relationships (Huddlestun, 1982).

REFERENCES CITED

Carrol, D., 1970, Clay Minerals: A guide to their x-ray identification: Boulder, Colorado, Geol. Soc. of America, Special Paper 126, 80 p.

Dixon, W.J., and Massey, F.J., 1969, Introduction to statistical analysis: New York, McGraw-Hill, 638 p.

Folk, R.L., 1965, Petrology of sedimentary rocks: Austin, Texas, Hemphill's, 159 p.

Gremillion, L.R., 1965, The origin of attapulgite in the Miocene strata of Florida and Georgia: Unpublished Ph.D. dissertation, Tallahassee, University of Florida, 159 p.

Guenther, W.C., 1964, Analysis of variance: Englewood Cliffs, New Jersey, Prentice-Hall, 199 p.

Heath, G.R., and Pisias, N.G., 1979, A method for quantitative estimation of clay minerals in North Pacific deep-sea sediments: Clays and Clay Min., v. 27, no. 3, p. 175-184.

Heron, S.D., Jr., and Johnson, H.S., Jr., 1966, Clay mineralogy, stratigraphy and structural setting of the Hawthorne Formation, Coosawhatchie District, South Carolina: Southeastern Geology, v. 7, no. 2, February, p. 51-63.

Huddlestun, P.F., 1982, The stratigraphic subdivision of the Hawthorne Group in Georgia, in Miocene of the Southeastern United States (abst.): Special Publication no. 25, Fla. Bureau of Geology, p. 183-184.

McClellan, G.H., 1964, Petrology of attapulgus clay in north Florida and southwest Georgia: Unpublished Ph.D. dissertation, Urbana, University of Illinois, 119 p.

Patterson, S.H., and Buie, B.F., 1974, Field conference on kaolin and Fuller's earth - Pt. II - Fuller's earth district of the Meigs-Attapulgus-Quincy District, Georgia and Florida: Georgia Geol. Survey Guidebook 14, p. 23-53.

Reynolds, W.R., 1962, The lithostratigraphy and clay mineralogy of the Tampa-Hawthorne sequence of peninsular Florida: Unpublished M.S. thesis, Florida State University, Tallahassee, Florida, 126 p.

Siegel, S., 1956, Nonparametric statistics for the behavioral sciences: New York, McGraw-Hill, 312 p.

Weaver, C.E., and Beck, K.C., 1977, Miocene of the S.E. United States: A model for chemical sedimentation in a peri-marine environment: Sed. Geol. v. 17, nos. 1/2, 234 p.

APPENDICES

APPENDIX A

COMPILATION OF X-RAY DIFFRACTION RESULTS FOR MAJOR CLAY MINERALS

SYMBOLS USED IN APPENDIX A

Formations (geologic units)

Pleistocene	2
Pliocene	3
Screven	4
(Hawthorne Group Undifferentiated)	5
Coosawhatchie	6
Marks Head	7
Parachucla	8
(Oligocene)	9
(Hawthorne group equivalent)	10
Altamaha	11
(Upper Miocene Hawthorne Group equivalent)	12

Other

Ar - aragonite

Gb - gibbsite

H-C - heulandite - clinoptilolite

Ap - apatite

D - dolomite

Cf - cristobalite

F - feldspar

E - erionite

G - geothite

An - analcime

C - chlorite

L - laumontite

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
1	80.0	26.9	0.0	0.0	73.1	0.0	6	H-C
	85.0	60.0	34.2	0.0	0.0	5.8	6	
	90.0	13.2	0.0	0.0	85.1	1.7	7	
	95.0	11.2	45.2	25.0	18.6	0.0	7	D
	100.0	6.5	33.1	23.2	37.2	0.0	7	D
	105.0	25.6	43.0	31.4	0.0	0.0	7	
	110.0	31.8	29.4	15.8	23.0	0.0	7	
	115.0	27.3	21.9	12.7	38.1	0.0	7	
	120.0	40.1	40.3	19.6	0.0	0.0	7	D
	125.0	35.1	42.7	22.2	0.0	0.0	7	
	130.0	27.2	37.6	0.0	35.2	0.0	7	D
	133.0	19.6	49.7	0.0	30.7	0.0	7	
	135.0	26.7	48.7	0.0	24.6	0.0	7	F
	141.0	34.4	65.6	0.0	0.0	0.0	7	Ap
	145.0	53.6	0.0	0.0	46.4	0.0	7	D
	145.0	28.0	38.0	0.0	34.0	0.0	7	D

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
1	152.0	23.4	44.4	0.0	32.2	0.0	7	
	160.0	34.1	22.9	10.2	32.8	0.0	7	F
	170.0	35.3	37.9	7.1	19.7	0.0	7	
	175.0	38.8	30.4	2.8	28.0	0.0	7	
	180.0	50.2	44.8	5.0	0.0	0.0	7	
	185.0	46.5	49.9	0.0	3.6	0.0	7	
2	157.5	28.0	72.0	0.0	0.0	0.0	2	D
	165.5	34.0	0.0	0.0	21.0	45.0	2	
	174.0	66.1	11.2	0.0	22.7	0.0	6	
	180.0	40.9	59.1	0.0	0.0	0.0	6	D
	190.0	35.8	53.7	10.5	0.0	0.0	6	D
	202.0	29.0	71.0	0.0	0.0	0.0	6	D
	205.0	29.5	70.5	0.0	0.0	0.0	6	D, Cr
	220.5	45.7	0.0	41.0	13.3	0.0	6	H-C, D
	221.0	53.2	0.0	36.9	9.9	0.0	6	D

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
2	225.0	49.8	0.0	37.7	12.5	0.0	6	H-C, D
	233.0	46.6	0.0	19.8	33.6	0.0	6	H-C, Ap
	236.0	68.1	4.4	0.0	27.5	0.0	6	D
	237.5	5.2	94.8	0.0	0.0	0.0	6	D
	239.0	18.1	81.9	0.0	0.0	0.0	7	D
	242.5	27.2	45.1	4.9	22.8	0.0	7	D
	244.0	19.8	80.2	0.0	0.0	0.0	7	D
	246.0	38.9	42.5	3.8	14.8	0.0	7	
	247.0	34.5	57.8	7.7	0.0	0.0	7	
	250.0	12.9	54.8	32.3	0.0	0.0	7	Ap
	253.0	37.9	24.6	37.5	0.0	0.0	7	D
	261.0	43.2	56.8	0.0	0.0	0.0	7	D
	267.5	72.1	4.0	1.1	22.8	0.0	8	D
	270.0	44.3	55.7	0.0	0.0	0.0	8	Ap, D
	275.0	42.2	15.8	26.8	15.2	0.0	8	Ap, D
	287.0	8.8	57.3	0.0	33.9	0.0	8	D

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
2	290.0	10.2	89.8	0.0	0.0	0.0	8	D
	294.5	30.3	47.4	22.3	0.0	0.0	8	D
3	78.0	41.3	0.0	0.0	18.0	40.7	3	
	80.5	22.9	77.1	0.0	0.0	0.0	6	
	87.5	43.1	19.7	0.0	0.0	37.2	6	
	90.0	25.0	24.0	0.0	0.0	51.0	6	
	92.5	4.5	42.1	0.0	0.0	53.4	6	
4	151.5	36.2	17.5	6.9	38.8	0.6	6	
	166.5	18.7	0.0	24.7	56.6	0.0	6	
	189.0	34.0	0.0	15.3	50.7	0.0	6	
	199.0	35.5	0.0	13.8	50.7	0.0	6	
	206.0	78.4	0.0	0.0	21.6	0.0	6	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
5	55.0	23.9	31.2	14.3	30.6	0.0	6	
	58.0	33.9	2.9	0.0	34.4	28.7	6	
	60.0	20.9	33.8	0.0	45.3	0.0	6	D
	65.0	23.3	15.8	12.2	48.7	0.0	6	D
	68.0	55.4	0.0	16.7	27.9	0.0	6	H-C, D
	72.0	45.3	0.0	14.2	40.5	0.0	6	H-C
	78.0	51.9	0.0	11.8	36.3	0.0	6	D
	86.0	29.2	0.0	16.4	48.6	5.8	6	H-C, D
	89.0	35.4	0.0	0.0	62.8	1.8	6	H-C, D
	102.0	57.1	7.9	5.7	26.6	2.7	6	D
	103.0	33.4	0.0	0.0	22.3	44.3	6	
	105.0	75.0	0.0	0.0	20.0	5.0	6	H-C, D
	111.0	54.1	14.1	10.3	19.4	2.1	6	D
	117.0	58.7	7.0	0.0	27.7	6.6	6	
	122.0	64.4	11.7	7.8	16.1	0.0	6	H-C, D, Ap

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
5	130.0	52.5	12.9	14.4	20.2	0.0	6	H-C
	163.0	34.1	0.0	0.0	21.2	44.7	6	
	164.0	45.0	0.0	0.0	23.2	31.8	6	H-C
	168.0	70.6	0.0	0.0	29.4	0.0	6	
	171.0	63.1	0.0	0.0	35.6	1.3	6	H-C
	175.0	35.7	0.0	11.9	52.4	0.0	6	D
	180.0	60.7	0.0	0.0	34.1	5.2	6	H-C
	184.0	70.9	0.0	0.0	29.1	0.0	6	H-C
	186.0	70.9	0.0	0.0	29.1	0.0	6	H-C
	189.0	40.7	22.2	4.8	32.3	0.0	6	D
	194.0	67.0	8.0	0.0	19.2	5.8	6	H-C
6	51.5	24.8	75.2	0.0	0.0	0.0	6	
	61.5	21.1	78.9	0.0	0.0	0.0	6	
	70.0	17.0	26.4	0.0	35.3	21.3	6	
	74.0	0.0	33.4	0.0	56.7	9.9	6	Ar

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
6	82.0	0.0	0.0	0.0	82.9	17.1	6	
	88.0	7.9	0.0	0.0	62.5	29.6	6	
	100.0	1.6	0.0	0.0	81.4	17.0	6	
	107.0	45.3	0.0	0.0	44.5	10.2	6	
	132.5	23.1	27.5	0.0	47.3	2.1	6	D
	142.5	14.3	26.6	0.0	56.0	3.1	6	
	155.5	10.5	33.4	0.0	56.1	0.0	6	
	170.0	26.5	0.0	0.0	69.1	4.4	6	
	179.0	21.1	29.5	0.0	47.5	1.9	6	D, F
	188.0	29.1	0.0	33.7	37.2	0.0	6	
	200.0	61.9	0.0	13.2	24.9	0.0	6	H-C, D, F
	228.0	48.4	11.3	0.0	40.3	0.0	6	
	240.0	54.3	0.0	5.7	40.0	0.0	6	
	260.0	55.2	0.0	4.1	40.7	0.0	6	H-C, Ap
	309.0	59.6	25.3	15.1	0.0	0.0	6	
	314.0	45.7	54.3	0.0	0.0	0.0	6	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
6	323.0	39.8	43.6	0.0	16.6	0.0	6	
	326.0	33.6	22.3	0.0	44.1	0.0	7	D
	335.0	30.8	16.4	32.8	20.0	0.0	7	D
	345.0	34.9	21.6	0.0	43.5	0.0	7	
	360.0	47.0	7.0	31.8	14.2	0.0	7	H-C, D
	374.0	60.0	0.0	4.8	35.2	0.0	7	H-C
	400.0	36.1	63.9	0.0	0.0	0.0	7	
	404.0	56.4	26.0	0.0	17.6	0.0	7	D
	418.0	31.2	17.1	11.1	40.6	0.0	7	
	438.0	52.7	5.3	19.0	20.9	2.1	7	H-C, D
	450.1	73.3	0.0	0.0	26.7	0.0	8	D
	465.0	56.4	0.0	0.0	43.6	0.0	8	H-C, D
7	11.0	0.0	0.0	0.0	31.7	68.3	2	L
	16.0	71.8	0.0	0.0	0.0	28.2	2	H-C
	21.0	71.4	0.0	0.0	0.0	28.6	2	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
7	25.0	67.1	0.0	0.0	24.5	8.4	2	
	30.0	39.4	0.0	0.0	17.6	43.0	2	
	33.0	36.3	0.0	0.0	21.4	42.3	2	L
	35.0	40.9	0.0	0.0	8.3	50.8	2	
	39.0	35.3	0.0	0.0	18.1	46.6	2	
	40.0	36.8	0.0	0.0	16.2	47.0	2	
	42.5	38.4	0.0	0.0	20.2	41.4	2	
	46.0	38.2	0.0	0.0	22.4	39.4	2	
	48.0	40.9	0.0	0.0	23.0	36.1	2	
	51.0	26.1	34.6	25.1	0.0	14.2	3	
	54.0	4.2	0.0	0.0	91.7	4.1	6	
	59.0	13.7	0.0	0.0	80.8	5.5	6	L
	64.0	17.5	34.6	0.0	47.9	0.0	6	L
	68.5	21.7	40.2	38.1	0.0	0.0	6	
	73.0	15.3	0.0	26.6	58.1	0.0	6	Ar

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
7	80.0	26.0	0.0	45.9	28.1	0.0	6	
	85.0	20.1	0.0	36.0	43.9	0.0	6	
	90.0	28.9	0.0	36.5	34.6	0.0	6	
	95.0	10.9	0.0	9.2	75.3	4.6	6	L
	100.0	0.0	0.0	8.8	91.2	0.0	6	
	105.0	45.4	0.0	15.2	39.4	0.0	6	
	110.0	43.8	0.0	16.0	40.2	0.0	6	
	115.0	47.2	0.0	22.7	30.1	0.0	6	
	120.0	38.7	0.0	10.8	50.5	0.0	6	L
	125.0	45.5	0.0	0.0	53.5	1.0	6	L
	130.0	37.3	35.2	27.5	0.0	0.0	6	F
	137.0	69.1	0.0	0.0	30.9	0.0	6	
	140.0	30.1	0.0	0.0	62.4	7.5	6	
	146.0	100.0	0.0	0.0	0.0	0.0	6	
	150.0	38.1	0.0	0.0	61.9	0.0	6	L

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
7	155.0	21.6	43.1	0.0	35.3	0.0	6	
	159.0	15.9	53.7	0.0	30.4	0.0	7	D
	163.0	23.9	76.1	0.0	0.0	0.0	7	D
	174.0	13.9	86.1	0.0	0.0	0.0	7	
	178.0	15.8	84.2	0.0	0.0	0.0	7	
	183.0	17.5	82.5	0.0	0.0	0.0	7	D
	194.0	23.1	30.0	31.5	15.4	0.0	7	Ap,D,F
	197.0	28.9	32.3	26.3	12.5	0.0	7	
	203.0	26.6	43.6	29.8	0.0	0.0	7	
	204.0	36.2	42.0	21.8	0.0	0.0	7	
	210.0	21.1	24.1	8.5	23.8	22.5	8	D
	212.0	28.0	30.3	12.6	19.0	10.1	8	
	216.0	31.1	24.8	14.9	23.3	5.9	8	H-C
	240.0	8.8	9.1	0.0	34.4	47.7	9	D
	247.0	86.2	0.0	0.0	13.8	0.0	9	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
8	8.0	72.3	0.0	0.0	0.0	27.7	2	C
	14.0	38.9	0.0	0.0	24.6	36.5	2	
	32.0	2.3	0.0	0.0	22.3	75.4	2	H-C
	35.0	21.0	0.0	0.0	18.2	60.8	2	L, H-C
	38.0	24.7	0.0	0.0	15.4	59.9	2	L
	47.0	13.5	0.0	0.0	7.7	78.8	2	
	55.0	11.0	0.0	0.0	22.0	67.0	2	
	59.8	38.0	0.0	0.0	9.9	52.1	2	
	62.5	32.2	0.0	0.0	37.4	30.4	5	
	65.0	17.1	0.0	0.0	68.7	14.2	5	
	78.0	31.6	3.6	0.0	56.3	8.5	5	
	82.0	19.4	17.3	20.9	42.4	0.0	6	Ap
	89.0	51.8	9.7	8.2	30.3	0.0	6	
	96.0	25.7	34.2	14.5	25.6	0.0	6	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
8	104.0	22.2	41.1	0.0	35.9	0.8	6	
	107.5	29.9	22.2	17.6	30.3	0.0	7	D
	110.0	24.8	27.0	22.6	25.6	0.0	7	D
	114.0	27.3	27.2	18.3	27.2	0.0	7	D
	125.0	25.2	32.4	13.6	28.8	0.0	7	D
	133.0	17.3	82.7	0.0	0.0	0.0	7	D
	142.5	13.0	71.1	15.9	0.0	0.0	7	
	144.5	30.0	0.0	0.0	70.0	0.0	8	E
	147.5	63.2	0.0	0.0	36.8	0.0	8	E
	155.0	56.8	0.0	0.0	39.2	4.0	9	E
9	20.0	12.2	0.0	0.0	35.0	52.8	3	F
	40.0	34.8	0.0	0.0	62.6	2.6	3	
	57.4	41.3	0.0	0.0	41.7	17.0	6	
	60.0	41.8	0.0	3.0	42.4	12.8	6	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
9	80.0	36.3	18.4	18.1	27.2	0.0	6	D
	87.0	28.0	0.0	7.7	64.3	0.0	6	H-C,L
	100.0	24.4	0.0	7.6	66.7	1.3	6	
	120.0	24.6	0.0	22.8	52.6	0.0	6	
	140.0	32.9	0.0	15.5	51.6	0.0	6	Ap
	160.0	58.0	0.0	0.0	42.0	0.0	6	D,Cr
	165.5	23.7	19.8	17.6	38.9	0.0	7	
	168.0	12.1	38.3	49.6	0.0	0.0	7	D,Ap
	168.5	13.1	81.6	0.0	0.0	5.3	7	Ap
	180.0	20.6	79.4	0.0	0.0	0.0	7	Cr,D
	181.4	13.1	86.9	0.0	0.0	0.0	7	
	188.0	21.5	78.5	0.0	0.0	0.0	7	F,D
	200.0	13.2	73.5	13.3	0.0	0.0	7	
	220.0	13.3	75.0	11.7	0.0	0.0	7	D,Ap
	225.0	14.3	85.7	0.0	0.0	0.0	7	D,Ap

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
9	227.0	27.7	72.3	0.0	0.0	0.0	7	Ap
	227.8	21.4	78.6	0.0	0.0	0.0	7	D,Ap
	229.0	71.3	0.0	0.0	28.7	0.0	7	D
	235.0	79.7	0.0	0.0	20.3	0.0	8	Ap
	250.0	75.3	0.0	0.0	24.7	0.0	8	H-C
10	15.0	28.3	0.0	0.0	6.0	65.7	3	
	20.0	25.7	0.0	0.0	4.2	70.1	3	
	40.0	47.7	0.0	0.0	27.8	24.5	3	
	58.3	59.2	0.0	0.0	11.2	29.6	3	
	60.0	40.2	0.0	7.4	52.4	0.0	6	
	80.0	25.3	0.0	16.0	58.7	0.0	6	D
	100.0	42.2	0.0	0.0	55.9	1.9	6	H-C
	107.0	50.0	0.0	20.9	29.1	0.0	6	D,H-C
	120.0	26.6	0.0	4.7	63.1	5.6	6	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
10	124.0	39.7	0.0	10.8	45.7	3.8	6	
	137.0	33.0	0.0	28.3	38.7	0.0	6	D,Ap
	140.0	32.7	0.0	21.4	45.9	0.0	6	Cr
	150.0	43.7	0.0	20.5	35.8	0.0	6	
	151.1	32.9	0.0	21.9	45.2	0.0	6	D
	160.0	48.5	0.0	0.0	51.5	0.0	6	
	164.0	55.8	0.0	0.0	44.2	0.0	6	
	165.0	39.7	0.0	0.0	60.3	0.0	6	
	165.8	33.2	0.0	0.0	66.8	0.0	6	
	173.0	67.9	0.0	0.0	32.1	0.0	6	
	180.0	16.0	84.0	0.0	0.0	0.0	7	D,Cr
	186.8	21.1	64.1	14.8	0.0	0.0	7	Cr
	200.0	19.7	80.3	0.0	0.0	0.0	7	D,Cr
	211.5	16.7	83.3	0.0	0.0	0.0	7	
	220.0	28.3	71.7	0.0	0.0	0.0	7	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
10	240.0	33.5	66.5	0.0	0.0	0.0	7	
	242.5	33.6	27.2	9.6	29.6	0.0	7	
	249.0	41.1	44.8	14.1	0.0	0.0	7	
	250.0	33.0	46.3	20.7	0.0	0.0	7	D
	253.0	29.1	22.0	23.8	25.1	0.0	9	D
	255.0	78.0	22.0	0.0	0.0	0.0	9	
	260.0	88.2	0.0	0.0	19.8	0.0	9	
11	55.8	39.7	0.0	0.0	8.4	51.9	2	
	65.0	37.2	0.0	0.0	5.9	56.9	2	
	72.0	47.0	0.0	0.0	11.1	41.9	2	
	80.0	46.1	0.0	0.0	38.6	15.3	6	
	85.0	60.0	0.0	0.0	34.1	5.9	6	
	90.0	59.7	0.0	0.0	30.2	10.1	6	
	95.0	63.9	0.0	0.0	9.9	26.2	6	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
11	100.0	30.0	22.6	21.3	26.1	0.0	6	D,Ap
	105.0	31.5	20.7	21.3	26.5	0.0	6	
	110.0	29.5	25.3	26.7	18.5	0.0	6	
	115.0	54.0	0.0	15.2	30.8	0.0	6	
	125.0	30.1	49.8	20.1	0.0	0.0	7	
12	5.1	100.0	0.0	0.0	0.0	0.0	6	
	7.0	93.8	0.0	0.0	6.2	0.0	6	
	9.0	76.0	0.0	0.0	24.0	0.0	6	
	11.0	84.1	0.0	0.0	14.7	1.2	6	
	15.2	79.1	0.0	0.0	20.9	0.0	6	
	19.0	66.3	0.0	0.0	31.7	2.0	6	F
	21.0	43.9	0.0	0.0	53.8	2.3	6	
	23.0	59.6	0.0	5.0	35.4	0.0	6	F
	26.0	53.5	0.0	0.0	46.5	0.0	6	F

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
12	30.1	22.2	72.3	5.7	0.0	0.0	7	D
	33.0	33.7	66.3	0.0	0.0	0.0	7	D
	36.0	19.3	54.3	0.0	26.4	0.0	7	D
	38.0	18.3	70.7	11.0	0.0	0.0	7	D
	43.0	34.7	47.6	17.7	0.0	0.0	7	D
	50.0	22.2	44.1	0.0	33.7	0.0	7	D
	57.0	37.8	20.5	25.6	16.1	0.0	7	D
	59.0	39.2	31.2	29.6	0.0	0.0	7	D
	65.0	77.5	4.8	17.7	0.0	0.0	8	D
	70.0	26.0	32.1	20.2	21.7	0.0	8	D
	75.0	44.3	55.7	0.0	0.0	0.0	8	
	77.0	34.0	13.1	6.6	46.3	0.0	9	
	79.0	31.2	21.5	6.2	41.1	0.0	9	
	80.0	47.5	23.2	10.2	19.1	0.0	9	D
	90.0	49.2	50.8	0.0	0.0	0.0	9	D

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
12	99.0	73.9	18.4	7.7	0.0	0.0	9	
	103.0	60.2	0.0	17.0	22.8	0.0	9	
13	48.0	52.8	15.4	14.9	16.9	0.0	3	D
	83.0	0.0	0.0	0.0	0.0	100.0	3	
	110.0	79.6	0.0	0.0	8.1	12.3	3	
	122.0	48.3	25.9	7.7	18.1	0.0	3	D
	132.0	94.2	0.0	0.0	0.0	5.8	3	
	140.0	75.2	14.9	0.0	9.9	0.0	6	Ap
	144.0	50.5	22.1	9.7	17.7	0.0	6	D
	147.0	32.3	67.7	0.0	0.0	0.0	6	F
	151.0	25.2	74.8	0.0	0.0	0.0	6	
	155.0	33.6	11.0	10.7	41.2	3.5	6	D
	160.0	67.1	22.9	0.0	10.0	0.0	6	D
	165.0	81.9	12.1	0.0	6.0	0.0	6	E,Ap,F

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
13	171.0	52.9	19.8	0.0	27.3	0.0	6	D
	179.0	73.1	0.0	0.0	26.9	0.0	6	D
	188.0	34.0	66.0	0.0	0.0	0.0	6	D
	193.0	35.1	64.9	0.0	0.0	0.0	6	D
	203.5	74.3	7.0	2.3	16.4	0.0	6	F,D
	205.5	86.5	6.6	1.7	5.2	0.0	6	F,D
	208.0	0.0	100.0	0.0	0.0	0.0	6	D
	211.5	6.0	91.9	0.0	0.0	2.1	6	D
	227.5	92.5	7.5	0.0	0.0	0.0	6	D
	239.0	88.9	11.1	0.0	0.0	0.0	6	D
	253.0	26.5	51.6	0.0	21.9	0.0	6	D
	256.0	83.8	0.0	0.0	7.2	9.0	6	
	264.0	66.9	0.0	0.0	33.1	0.0	6	Cr,F
	267.0	61.1	0.0	0.0	38.9	0.0	7	F
	288.0	47.4	0.0	52.6	0.0	0.0	8	D

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
13	291.0	44.1	0.0	48.4	7.5	0.0	8	D
	294.0	23.2	32.0	29.7	15.1	0.0	8	D
	296.0	26.5	27.3	26.5	19.7	0.0	8	D
	298.0	47.2	15.8	15.2	21.8	0.0	8	D
	303.0	0.0	100.0	0.0	0.0	0.0	8	D
	305.8	30.4	35.3	0.0	34.3	0.0	8	D
	309.5	87.6	0.0	0.0	12.4	0.0	8	
	312.0	23.9	17.1	30.4	28.6	0.0	8	D
14	9.9	0.0	0.0	0.0	6.1	93.9	7	
	20.0	0.0	0.0	0.0	9.3	90.7	7	
	29.0	63.9	0.0	0.0	0.0	36.1	3	
	34.0	46.8	6.7	22.7	18.5	5.3	3	
	39.0	40.6	16.8	42.6	0.0	0.0	3	Ap
	41.0	35.6	21.9	42.5	0.0	0.0	3	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
14	45.0	19.6	42.2	38.2	0.0	0.0	7	
	50.0	22.5	42.0	35.5	0.0	0.0	7	
	53.0	25.7	46.5	27.8	0.0	0.0	7	
	54.0	37.9	34.8	27.3	0.0	0.0	7	
	61.0	45.0	14.5	14.5	26.0	0.0	7	
	64.0	17.4	43.1	39.5	0.0	0.0	7	Ap,D
	66.0	13.8	43.0	38.3	0.0	4.9	7	D
	69.0	18.5	37.0	44.5	0.0	0.0	7	D
	74.0	9.0	52.0	39.0	0.0	0.0	7	D
	79.0	24.9	29.7	45.4	0.0	0.0	7	Ap
	81.0	28.4	33.1	38.5	0.0	0.0	7	Ap
	86.0	39.0	35.2	25.8	0.0	0.0	7	
	89.0	29.0	55.5	15.5	0.0	0.0	7	
	91.0	21.8	68.1	10.1	0.0	0.0	7	Cr
	94.0	20.4	42.9	36.7	0.0	0.0	7	Cr

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
14	99.0	26.7	73.3	0.0	0.0	0.0	7	Cr
	106.0	28.4	33.5	14.0	24.1	0.0	7	
	109.0	23.2	28.5	31.5	16.8	0.0	7	F
	114.0	33.0	42.8	24.2	0.0	0.0	7	
	116.0	36.0	39.4	24.6	0.0	0.0	7	
	124.0	30.6	50.0	19.4	0.0	0.0	7	
	131.0	77.5	0.0	0.0	11.6	10.9	8	
	148.0	71.0	0.0	0.0	29.0	0.0	8	Ap,H-C
	150.0	82.5	0.0	0.0	11.2	6.3	8	Ap
	152.0	77.3	0.0	0.0	22.8	0.0	8	Ap
	163.0	13.8	6.7	6.8	9.6	63.1	8	
	164.0	38.9	9.3	0.0	5.8	46.0	8	
15	29.0	68.5	0.0	31.5	0.0	0.0	8	
	36.0	60.6	0.0	39.4	0.0	0.0	8	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
15	45.0	26.3	0.0	0.0	0.0	73.7	8	F
	56.0	34.9	0.0	0.0	0.0	65.1	8	Cr
	59.0	24.7	0.0	0.0	19.3	56.0	8	
	66.0	51.1	0.0	11.7	23.1	14.2	8	
	72.5	51.1	0.0	1.5	16.2	31.2	8	
	75.6	21.1	0.0	0.0	0.0	78.9	8	F
	78.0	22.8	0.0	0.0	27.9	49.3	8	F
	79.0	49.9	0.0	0.0	0.0	50.1	8	F
	80.0	48.2	0.0	0.0	0.0	51.8	8	F
	82.5	54.7	0.0	0.0	16.0	29.3	8	F
	86.0	53.5	0.0	0.0	18.5	28.0	8	F
	93.0	61.5	0.0	0.0	9.6	28.9	8	F
	96.0	60.3	0.0	0.0	18.6	21.1	8	F
	105.0	72.8	0.0	0.0	27.2	0.0	8	H-C
	107.0	72.7	0.0	0.0	27.3	0.0	8	Ap,H-C

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
15	111.0	73.9	0.0	0.0	26.1	0.0	8	Ap,H-C
	118.0	57.8	0.0	0.0	42.2	0.0	8	Ap,H-C,F
	125.0	52.2	25.3	22.5	0.0	0.0	8	D
	129.0	67.4	0.0	32.6	0.0	0.0	8	D,Ap
	131.0	0.0	0.0	0.0	0.0	100.0	8	
	139.0	41.5	0.0	8.5	50.0	0.0	8	F
	144.0	88.9	0.0	0.0	11.1	0.0	8	
	145.9	67.5	0.0	0.0	32.5	0.0	8	F
	148.0	100.0	0.0	0.0	0.0	0.0	9	
	150.0	70.8	0.0	0.0	0.0	29.2	9	F,Ap
	176.0	56.1	0.0	0.0	43.9	0.0	9	Ar,Ap
	185.0	100.0	0.0	0.0	0.0	0.0	9	
	194.0	72.4	0.0	0.0	15.7	11.9	0	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
16	23.0	7.8	0.0	0.0	0.0	92.2	3	
	35.0	1.1	0.0	0.0	6.6	92.2	3	H-C,Cr
	36.1	37.4	0.0	0.0	0.0	62.6	3	
	40.0	25.3	0.0	0.0	12.9	61.8	7	Ap
	45.0	37.8	38.9	23.3	0.0	0.0	7	Ap
	46.0	33.4	48.0	18.6	0.0	0.0	7	
	47.0	14.8	48.1	37.1	0.0	0.0	7	Ap
	48.0	35.1	47.4	17.5	0.0	0.0	7	
	55.0	30.3	30.3	39.4	0.0	0.0	7	
	59.0	33.2	33.8	33.0	0.0	0.0	7	
	60.0	32.6	67.4	0.0	0.0	0.0	7	
	62.0	31.0	51.0	18.0	0.0	0.0	7	
	66.0	29.8	37.7	32.5	0.0	0.0	7	
	70.0	28.7	51.1	20.2	0.0	0.0	7	
	77.0	41.7	44.2	14.1	0.0	0.0	7	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
16	83.0	32.4	42.2	25.4	0.0	0.0	7	
	84.0	29.2	43.8	27.0	0.0	0.0	7	
	85.0	26.9	16.6	26.9	29.6	0.0	7	
	86.2	39.3	33.0	27.7	0.0	0.0	7	
	86.6	66.0	12.0	12.5	0.0	9.5	7	
	89.0	51.9	25.0	23.1	0.0	0.0	7	
	90.0	71.5	0.0	0.0	0.0	28.5	7	F
	95.0	57.3	6.5	8.7	10.2	17.3	7	Ap
	103.0	45.5	30.3	24.2	0.0	0.0	7	
	105.0	86.4	13.6	0.0	0.0	0.0	8	H-C
	107.0	85.9	14.1	0.0	0.0	0.0	8	H-C
	110.0	74.6	25.4	0.0	0.0	0.0	8	
	116.0	61.2	38.8	0.0	0.0	0.0	8	
	120.0	94.2	0.0	0.0	5.8	0.0	8	
	125.0	70.5	0.0	0.0	29.5	0.0	8	H-C

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
16	135.0	82.2	0.0	0.0	17.8	0.0	8	H-C
	140.0	86.3	0.0	0.0	13.7	0.0	8	H-C
	150.0	82.2	0.0	0.0	17.8	0.0	8	
	157.0	74.3	0.0	0.0	25.7	0.0	8	F
	160.0	24.2	0.0	0.0	75.8	0.0	8	Ap
	162.0	48.4	0.0	0.0	51.6	0.0	8	Ap
	165.0	52.8	0.0	0.0	47.2	0.0	8	Ap
	170.0	73.7	0.0	26.3	0.0	0.0	9	
17	23.0	0.0	0.0	0.0	0.0	100.0	3	G
	24.9	0.0	0.0	0.0	0.0	100.0	3	G
	37.0	19.1	49.1	31.8	0.0	0.0	7	Ap
	38.0	34.9	40.8	24.3	0.0	0.0	7	
	41.0	26.1	44.5	29.4	0.0	0.0	7	Ap
	43.0	41.9	21.9	20.0	0.0	16.2	7	F, Ap

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
17	44.0	32.5	10.1	14.7	18.9	23.8	Ap	
	45.0	31.1	39.2	29.7	0.0	0.0	7	
	49.0	20.9	22.1	57.0	0.0	0.0	7	
	51.0	20.4	35.2	44.4	0.0	0.0	7	
	60.0	26.4	30.4	43.2	0.0	0.0	7	
	62.0	21.4	39.6	39.0	0.0	0.0	7	
	63.0	21.7	30.4	47.9	0.0	0.0	7	
	64.0	13.7	22.8	27.5	0.0	0.0	7	
	65.0	21.0	41.3	30.0	0.0	7.7	7	
	70.0	21.8	49.3	28.9	0.0	0.0	7	
	72.0	23.0	77.0	0.0	0.0	0.0	7	
	74.0	26.7	48.9	24.4	0.0	0.0	7	
	75.0	27.3	40.7	16.3	0.0	15.7	7	
	76.0	100.0	0.0	0.0	0.0	0.0	7	
	79.0	24.7	46.9	28.4	0.0	0.0	7	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
17	82.0	24.3	53.3	22.4	0.0	0.0	7	
	85.0	26.2	52.8	21.0	0.0	0.0	7	D
	89.0	100.0	0.0	0.0	0.0	0.0	7	F
	91.0	35.4	64.6	0.0	0.0	0.0	7	
	92.0	54.4	23.2	22.4	0.0	0.0	7	
	94.0	31.4	34.0	34.6	0.0	0.0	7	
	95.0	43.7	23.6	32.7	0.0	0.0	7	
	96.0	40.5	41.5	18.0	0.0	0.0	7	D
	97.0	42.7	25.8	14.8	16.7	0.0	7	D
	98.0	49.3	24.0	26.7	0.0	0.0	7	
	99.0	46.2	20.1	16.1	17.6	0.0	7	
	101.0	53.5	17.9	28.6	0.0	0.0	7	
	101.7	24.0	25.0	21.5	0.0	29.5	7	
	103.0	45.6	33.2	21.2	0.0	0.0	7	
	111.0	40.7	48.0	11.3	0.0	0.0	7	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
17	112.0	44.4	12.5	20.5	22.6	0.0	7	
	117.0	44.7	20.4	20.4	14.5	0.0	7	
	118.0	38.3	0.0	11.2	50.5	0.0	7	H-C
	118.5	67.8	0.0	0.0	32.2	0.0	7	H-C
	120.0	91.3	8.7	0.0	0.0	0.0	8	
	121.0	70.5	0.0	0.0	29.5	0.0	8	H-C, Ap
	122.0	77.7	0.0	0.0	22.3	0.0	8	H-C, Ap
	123.0	100.0	0.0	0.0	0.0	0.0	8	
	124.0	69.8	0.0	0.0	30.2	0.0	8	Ap, H-C
	125.0	75.6	0.0	8.7	15.7	0.0	8	Ap, H-C
	126.0	60.4	0.0	0.0	39.6	0.0	8	Ap,H-C
	127.0	72.6	0.0	0.0	27.4	0.0	8	Ap,H-C
	130.0	66.0	0.0	0.0	34.0	0.0	8	Ap,H-C
	132.9	70.7	13.7	0.0	15.6	0.0	8	H-C,D
	135.0	67.1	20.2	0.0	12.7	0.0	8	H-C,F

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
Cont.	136.0	60.8	18.7	0.0	20.5	0.0	8	H-C
17	138.0	64.3	35.7	0.0	0.0	0.0	8	F
	142.0	47.5	24.2	6.8	21.5	0.0	8	
	143.0	63.3	14.3	0.0	22.4	0.0	8	H-C,F
	148.0	66.6	0.0	0.0	28.1	5.3	8	
	152.0	100.0	0.0	0.0	0.0	0.0	8	
	154.1	84.5	0.0	0.0	15.5	0.0	9	H-C
	157.0	80.6	19.4	0.0	0.0	0.0	9	
	184.0	81.4	18.6	0.0	0.0	0.0	9	
18	57.0	0.0	0.0	0.0	0.0	98.1	2	Ch
	70.0	18.7	0.0	0.0	40.5	40.8	2	F
	75.1	25.2	74.8	0.0	0.0	0.0	6	
	76.0	29.0	71.0	0.0	0.0	0.0	6	
	80.0	24.1	75.9	0.0	0.0	0.0	6	
	85.0	21.5	54.5	24.0	0.0	0.0	6	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
18	90.0	38.6	0.0	31.3	30.1	0.0	6	
	95.0	35.5	33.6	30.9	0.0	0.0	7	
	100.0	30.4	49.3	20.3	0.0	0.0	7	
19	2.0	8.5	0.0	0.0	0.0	86.0	3	Ch
	20.0	1.8	0.0	0.0	19.8	78.4	3	F
	40.0	33.9	0.0	0.0	9.1	57.0	3	
	60.0	31.3	0.0	0.0	56.0	12.7	6	
	80.0	66.1	0.0	0.0	31.3	2.6	6	D
	100.0	58.2	0.0	0.0	41.8	0.0	6	D
	120.0	66.3	0.0	0.0	33.7	0.0	6	
	160.0	60.9	0.0	0.0	39.1	0.0	6	
	180.0	17.4	82.6	0.0	0.0	0.0	7	D
	200.0	46.9	43.5	9.6	0.0	0.0	7	
	220.0	49.0	51.0	0.0	0.0	0.0	7	
	240.0	100.0	0.0	0.0	0.0	0.0	9	F, D

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
20	12.5	42.9	4.5	0.0	52.6	0.0	6	
	15.5	32.1	0.0	0.0	21.2	46.7	6	
	22.0	86.3	0.0	1.9	11.8	0.0	6	
	23.0	68.1	8.3	13.6	10.0	0.0	6	
	26.0	69.0	3.1	8.3	19.6	0.0	6	
	31.0	62.2	0.0	0.0	37.8	0.0	6	
	35.0	66.2	12.8	6.7	14.3	0.0	6	
	37.0	56.5	16.0	4.2	23.3	0.0	6	
	41.5	67.3	9.5	0.0	23.2	0.0	6	
	48.0	69.0	31.0	0.0	0.0	0.0	7	
	50.5	86.5	13.5	0.0	0.0	0.0	7	
	53.0	7.3	89.1	3.6	0.0	0.0	7	
	58.5	12.9	81.9	5.2	0.0	0.0	7	
	62.0	15.4	79.9	4.7	0.0	0.0	7	Cr
	71.0	0.0	100.0	0.0	0.0	0.0	7	
	75.0	0.7	99.3	0.0	0.0	0.0	7	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
21	195.0	100.0	0.0	0.0	0.0	0.0	6	E
	202.0	22.5	77.5	0.0	0.0	0.0	6	
	210.0	43.0	0.0	0.0	57.0	0.0	6	
	216.0	35.0	0.0	0.0	65.0	0.0	6	
	225.0	48.1	23.3	0.0	18.3	10.3	6	
	230.0	35.2	26.6	19.9	16.1	2.2	6	
	243.0	49.2	18.2	0.0	32.6	0.0	6	
	255.0	53.6	10.0	29.0	7.4	0.0	6	D
	265.0	44.9	25.6	0.0	29.5	0.0	6	D
	270.0	22.4	27.2	0.0	50.4	0.0	6	D
	282.0	74.2	0.0	0.0	25.8	0.0	6	
	285.0	60.4	8.2	0.0	31.4	0.0	6	
	290.0	58.1	9.0	0.0	32.9	0.0	6	
	300.0	52.6	26.6	0.0	20.8	0.0	6	D
	310.0	73.6	5.4	11.8	9.2	0.0	7	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
21	313.0	39.2	26.3	0.0	34.5	0.0	7	D
	322.0	33.8	37.8	0.0	28.4	0.0	7	
	331.0	29.6	70.4	0.0	0.0	0.0	7	D
	333.5	15.2	46.3	0.0	38.5	0.0	7	
	338.0	0.0	100.0	0.0	0.0	0.0	7	D
	343.0	28.0	43.9	0.0	28.1	0.0	7	D
	362.0	83.8	9.0	2.5	4.7	0.0	7	D
	370.0	72.2	9.7	13.4	4.7	0.0	7	H-C,D
	380.0	11.1	88.9	0.0	0.0	0.0	7	D
	385.0	28.5	71.5	0.0	0.0	0.0	7	
	399.0	32.2	67.8	0.0	0.0	0.0	7	D
	405.0	33.9	27.1	39.0	0.0	0.0	7	D
	433.0	76.8	0.0	0.0	23.2	0.0	8	
	438.0	82.8	0.0	1.8	15.4	0.0	8	
	445.0	92.3	0.0	0.0	7.7	0.0	8	H-C

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
21	452.0	87.8	0.0	0.0	12.2	0.0	8	
	457.0	87.0	0.0	0.0	13.0	0.0	8	H-C
	471.5	76.0	0.0	0.0	24.0	0.0	8	
	480.0	90.9	0.0	0.0	9.1	0.0	8	
22	77.0	50.9	0.0	0.0	11.8	37.3	2	
	80.0	50.1	0.0	0.0	11.1	38.8	2	
	82.5	0.0	0.0	0.0	29.3	70.7	2	
	122.0	16.8	83.2	0.0	0.0	0.0	7	D,Ap
23	1.9	0.0	0.0	0.0	0.0	96.0	4	Ch
	13.0	0.0	0.0	0.0	0.0	99.0	4	Ch
	28.5	0.5	0.0	0.0	0.0	99.0	11	Ch
	31.3	0.0	0.0	0.0	16.9	83.1	11	
	38.5	47.3	0.0	0.0	12.0	40.7	11	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
23	45.0	56.8	0.0	0.0	9.0	34.2	11	
	58.0	39.1	0.0	0.0	19.0	41.9	11	
	59.5	37.9	0.0	0.0	7.8	54.3	11	
	65.5	52.1	0.0	0.0	8.4	39.5	11	
	66.0	36.4	0.0	0.0	11.9	51.7	11	
	76.0	93.7	0.0	0.0	6.3	0.0	11	
	78.5	91.3	0.0	0.0	8.7	0.0	11	
	83.0	89.7	0.0	0.0	10.3	0.0	11	
	90.0	37.4	32.2	0.0	30.4	0.0	11	L
	99.0	70.8	0.0	0.0	17.9	11.3	11	
	110.0	82.5	0.0	0.0	17.5	0.0	11	
	120.5	86.6	0.0	0.0	3.4	0.0	11	
	126.0	90.0	0.0	0.0	10.0	0.0	11	
	130.0	82.8	0.0	0.0	12.5	4.7	11	
	134.0	100.0	0.0	0.0	0.0	0.0	11	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
23	142.0	87.2	0.0	0.0	12.8	0.0	11	
	149.0	72.7	0.0	0.0	13.3	14.0	11	F
	150.0	46.5	0.0	0.0	11.0	42.5	11	F
	156.0	53.8	11.8	0.0	20.5	13.9	8	
	160.0	74.3	7.0	0.0	18.7	0.0	8	
	164.0	51.2	48.8	0.0	0.0	0.0	8	
	166.0	40.6	59.4	0.0	0.0	0.0	8	
	169.5	10.6	21.0	0.0	68.4	0.0	8	
	171.8	46.6	53.4	0.0	0.0	0.0	8	Ar
	182.5	31.7	49.9	0.0	18.4	0.0	8	
	185.0	45.8	54.2	0.0	0.0	0.0	8	F
	192.0	48.4	33.9	0.0	17.7	0.0	8	F
24	166.0	56.3	10.5	0.0	30.3	2.9	6	D
	185.0	32.0	16.4	19.8	28.1	3.7	6	D

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
24	189.0	36.4	16.4	8.5	34.7	4.0	6	D
	192.5	44.2	55.8	0.0	0.0	0.0	6	D
	194.0	27.1	9.0	0.0	63.9	0.0	6	
	213.0	22.9	33.4	0.0	43.7	0.0	6	D
	218.0	20.9	23.1	0.0	54.3	1.7	6	D
	225.0	28.2	15.3	0.0	56.5	0.0	6	D
	235.0	16.1	35.2	0.0	48.7	0.0	6	D
	241.0	14.0	18.5	0.0	67.5	0.0	6	D
	245.0	18.3	28.2	0.0	53.5	0.0	6	H-C,D
25	90.0	9.6	42.0	4.0	44.4	0.0	7	D
	100.0	24.1	63.8	12.1	0.0	0.0	7	D,Ap
	110.0	24.0	37.5	22.7	15.8	0.0	7	D
	120.0	14.9	66.4	18.7	0.0	0.0	7	
	127.0	10.3	66.2	4.8	18.7	0.0	7	F

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
26	51.0	45.1	0.0	0.0	54.9	0.0	3	
	55.0	63.8	20.5	0.0	0.0	15.7	3	
	56.0	42.9	13.0	0.0	28.4	15.7	3	
	58.0	40.3	0.0	0.0	44.0	15.7	3	
	59.0	35.4	0.0	0.0	52.6	12.0	6	
	61.5	92.4	0.0	0.0	0.0	7.6	6	
	81.0	70.1	0.0	0.0	29.9	0.0	6	D
	83.0	46.9	14.6	6.4	32.1	0.0	6	
	96.0	58.0	0.0	0.0	42.0	0.0	6	
	99.0	55.7	0.0	0.0	44.3	0.0	6	
	101.0	60.6	0.0	0.0	39.4	0.0	6	
	105.0	35.7	24.5	0.0	39.8	0.0	6	D
	122.0	31.3	25.0	9.2	34.5	0.0	6	D
	136.0	42.3	0.0	21.7	36.0	0.0	6	D
	160.0	36.3	0.0	18.1	45.6	0.0	6	D
	170.0	42.1	0.0	22.8	35.1	0.0	6	D,H-C

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
26	180.0	54.4	0.0	45.6	0.0	0.0	6	F,D
	190.0	42.5	0.0	24.8	32.7	0.0	6	D
	195.0	38.4	0.0	24.2	37.4	0.0	6	D
	205.0	42.1	0.0	0.0	57.9	0.0	6	F,D,H-C
	222.0	52.9	11.0	8.0	28.1	0.0	6	H-C,D
	243.0	39.9	0.0	3.0	57.1	0.0	6	H-C,F,Ap
	250.0	43.5	7.4	22.1	27.0	0.0	6	H-C,F
	275.0	52.9	0.0	0.0	47.1	0.0	6	D
	280.0	58.2	0.0	0.0	30.9	10.9	6	D
	292.5	44.4	0.0	0.0	55.6	0.0	6	D,H-C
	302.0	39.5	0.0	0.0	60.5	0.0	6	H-C
	307.0	12.9	47.3	0.0	39.8	0.0	7	D
	357.0	4.3	83.1	12.6	0.0	0.0	7	D
	359.0	10.3	55.7	0.0	34.0	0.0	7	D
	372.0	52.7	0.0	12.9	34.4	0.0	7	D,H-C

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
26	380.0	28.2	0.0	29.3	42.5	0	7	D
	405.0	46.0	0.0	4.7	35.8	13.5	7	
	407.0	37.7	0.0	23.0	39.3	0.0	7	D
	425.0	44.8	0.0	15.8	39.4	0.0	7	D
	433.0	46.6	0.0	15.5	37.9	0.0	7	D
	449.0	33.0	15.3	31.9	19.8	0.0	7	D
	451.0	26.1	11.5	28.7	33.7	0.0	7	D
	456.0	43.4	11.4	22.2	23.0	0.0	7	D
	462.0	55.4	0.0	0.0	44.6	0.0	7	H-C
	486.0	25.4	74.6	0.0	0.0	0.0	7	D
	511.0	33.0	15.2	0.0	51.8	0.0	7	D
	520.0	62.5	9.1	1.3	27.1	0.0	7	H-C,D
	522.0	64.2	0.0	0.0	35.8	0.0	7	H-C
	549.0	69.6	0.0	0.0	20.2	10.2	8	
	556.0	75.2	0.0	0.0	24.8	0.0	8	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
26	574.0	58.4	0.0	0.0	41.6	0.0	8	D
	594.0	50.4	0.0	0.0	49.6	0.0	8	D
	604.0	41.6	0.0	0.0	33.3	25.1	8	D, H-C
	618.0	51.8	0.0	0.0	22.6	25.6	8	D
	643.0	100.0	0.0	0.0	0.0	0.0	9	
27	57.0	14.5	0.0	0.0	7.3	78.2	12	
	59.9	14.5	16.6	0.0	22.9	46.0	12	Ap
	68.0	18.1	23.4	0.0	36.8	21.7	12	Ap
	70.6	21.9	13.5	0.0	35.9	28.7	12	
	72.3	14.0	19.3	0.0	38.9	27.8	12	
	79.8	13.2	33.7	0.0	38.2	14.9		
	84.2	15.1	43.4	0.0	38.2	3.3	12	
	89.5	22.4	0.0	31.3	46.3	0.0	6	Ap
	95.4	30.1	0.0	31.8	36.8	1.3	6	Ap

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
27	100.0	34.0	0.0	31.3	34.7	0.0	6	
	110.1	31.7	0.0	23.7	44.0	0.6	6	
	114.7	21.1	0.0	32.3	46.3	0.3	6	Ap
	190.2	20.1	15.2	23.8	40.9	0.0	6	
	220.3	24.0	47.8	28.2	0.0	0.0	6	
	225.2	25.7	46.9	27.4	0.0	0.0	6	
	230.0	35.1	12.2	13.2	39.5	0.0	6	
	235.0	29.4	54.6	16.0	0.0	0.0	8	C
	240.0	35.1	48.0	16.9	0.0	0.0	8	D
	244.9	39.9	17.8	23.7	18.6	0.0	8	Ap
	250.0	36.4	22.5	12.3	28.8	0.0	8	
	254.7	30.7	0.0	30.4	38.9	0.0	8	Ap,D
	287.2	15.8	0.0	44.5	39.7	0.0	8	
	289.3	32.8	0.0	31.0	36.2	0.0	8	

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
28	298.9	9.4	0.0	0.0	10.8	79.8	3	
	301.1	9.2	0.0	0.0	11.1	79.7	3	Ar
	308.7	4.4	0.0	0.0	16.4	79.2	3	
	311.6	9.0	0.0	0.0	15.4	75.6	3	Ar
	313.9	9.3	0.0	0.0	21.1	69.6	3	Ar
	316.8	10.3	0.0	0.0	18.5	62.8	3	Ar,Ch
	318.5	14.2	5.8	0.0	14.5	65.5	3	Ar
	319.4	5.6	3.3	0.0	10.5	72.6	3	Ar,Ch
	321.8	16.5	5.6	0.0	20.1	57.8	3	Ar
	323.3	11.1	7.1	0.0	25.4	56.4	3	Ar
	327.1	2.6	0.0	0.0	17.9	79.5	3	F,Ar,D
	329.7	5.9	5.7	1.5	0.0	86.9	3	Ar
	344.6	6.4	6.6	0.0	18.9	68.0	10	
	345.7	14.3	74.4	0.0	11.3	0.0	10	Ap
	347.8	10.6	7.8	0.0	18.5	63.1	10	Ar

APPENDIX A

PERCENT OF CLAY-MINERAL FRACTION

Core Cont.	Depth Sampled Feet	Smectite	Palygorskite	Sepiolite	Illite	Kaolinite	Formation	Other
28	385.0	16.0	84.0	0.0	0.0	0.0	10	
	390.2	59.0	0.0	0.0	22.2	18.8	10	
	416.3	18.6	81.4	0.0	0.0	0.0	10	
	421.5	20.1	79.9	0.0	0.0	0.0	10	
	432.4	14.4	85.6	0.0	0.0	0.0	10	
	488.1	8.0	76.8	15.2	0.0	0.0	10	Ap
	514.1	12.2	87.8	0.0	0.0	0.0	10	
	575.5	11.1	60.2	28.7	0.0	0.0	10	D

APPENDIX B

COMPILATION OF CHLORITE COMPOSITIONS

APPENDIX B

CORE	DEPTH SAMPLED (FEET)	PERCENT CHLORITE* OF CLAY-MINERAL FRACTION	FORMATION
18	57.0	1.8	(Pleistocene-Pliocene)**
19	2.0	5.5	(Pleistocene-Pliocene)
23	1.9	4.0	Screven
23	13.0	1.0	Screven
23	28.5	0.5	Altamaha
28	316.8	8.4	(Pleistocene-Pliocene)
28	319.4	8.0	(Pleistocene-Pliocene)

* Calculated from diffraction peak area corrected by a factor of 1.1

** Composed of Satilla, Cypresshead, and Nashua Formations

APPENDIX C

CORE LOCATIONS, DESIGNATIONS,

AND DEPTHS

APPENDIX C

Locations are given by latitude and longitude unless indicated otherwise. Sources of information are indicated by letters within parentheses. A code for the sources is given at end of the appendix.

DATA SOURCES

C - Georgia Geologic Survey County Well Record
F - Florida Bureau of Geology
S - South Carolina Geologic Survey
P - Paul Huddlestun
G- Georgia Power Company
U - U.S. Geological Survey

Core	Source	Location	Elevation (Land Surface)	Total Depth
1	Ga. Power B-41	32°25'41"N-81°14'50"W (G)	90' (G)	232' (G)
2	Fla. Bureau of Geology W-8400	29°42'47"N-81°50'29"W (F)	210' (F)	302' (F)
3	Fla. Bureau of Geology W-10482	4N-23E-Section 26** (F)	100' (F)	98' (F)
4	GGS 1337, Bryan 2	31°48'17"N-81°12'45"W (P)	19' (P)	220' (F)
5	GGS 1339, Camden 2	31°02'48"N-81°46'00"W (C)	22' (C)	195' (P)
6	GGS 3185, Charlton 2	30°49'12"N-82°00'48"W (C)	75' (C)	480' (C)
7	GGS 535, Chatham 1	31°59'24"N-81°02'50"W (P)	12' (P)	278' (P)
8	GGS 1341, Chatham 3	32°01'50"N-80°57'54"W (P)	13' (P)	159' (P)
9	GGS 3139, Chatham 14	32°04'29"N-81°09'18"W (P)	13' (P)	330' (P)
10	GGS 3135, Chatham 15	32°11'20"N-81°11'44"W (P)	20' (P)	322' (P)
11	GGS 1445, Chatham 13	31°58'23"N-80°59'48"W (P)	12' (P)	270' (P)
12	S. C. Geologic Survey Dawson Landing	32°33'35"N-80°54'23"W (S)	12' (S)	125' (S)
13	Fla. Bureau of Geology W-10488	29°55'40"N-82°02'00"W (F)	239' (F)	332' (F)

APPENDIX C (Cont'd)

Core	Source	Location	Elevation (Land Surface)	Total Depth
14	GGS 2179, Effingham 6	32°31'17"N-81°14'47"W (C)	95' (P)	180' (P)
15	GGS 3108, Effingham 10	32°34'22"N-81°25'03"W (C)	112' (C)	198' (C)
16	GGS 3109, Effingham 11	32°33'07"N-81°22'34"W (C)	113' (C)	188' (C)
17	GGS 3110, Effingham 12	32°31'47"N-81°19'57"W (C)	109' (C)	210' (C)
18	GGS 1394, Chatham 10	31°59'35"N-80°51'14"W (C)	7' (C)	222' (C)
19	GGS 3155, Effingham 14	32°21'15"N-81°12'50"W (C)	68' (C)	276' (C)
20	Fla. Bureau of Geology W-11486	29°34'54"N-82°08'07"W (F)	75' (F)	145' (F)
21	Fla. Bureau of Geology W-12360	4S-22E Sectioln 25-N.E. of S.E. ** (F)	210' (F)	493' (F)
22	GGS 1164, Petit Chou	31°56'38"N-80°55'40"W (P)	8' (P)	286' (P)
23	GGS 3198, Screven 8	32°41'25"N-81°30'29"W (P)	205' (P)	212' (P)
24	Fla. Survey W-10473	2S-22 E-Section 15-S.E. of S.E. ** (F)	166' (F)	288' (F)
25	U.S.G.S., Chatham 484	32°03'58"N-80°58'49"W (U)	10' (U)	842' (U)
26	GGS 3512, Wayne 2	31°27'47"N-81°51'21"W (P)	59.4' (P)	687' (P)
27	U.S.G.S 6002	31°08.57'N-80°31.05"W (U)	-106'* (U)	1000' (U)
28	U.S.G.S. 6004	32°03.98'N-79°05.86"W (U)	-570'* (U)	1010' (U)

* Offshore cores
** Township-Range-Section-Quadrant

For convenience in selecting our reports from your bookshelves, they are color-keyed across the spine by subject as follows:

Red	Valley and Ridge mapping and structural geology
Dk. Purple	Piedmont and Blue Ridge mapping and structural geology
Maroon	Coastal Plain mapping and stratigraphy
Lt. Green	Paleontology
Lt. Blue	Coastal Zone studies
Dk. Green	Geochemical and geophysical studies
Olive	Economic geology Mining directory
Dk. Blue	Hydrology
Yellow	Environmental studies Engineering studies
Dk. Orange	Bibliographies and lists of publications
Brown	Petroleum and natural gas
Black	Field trip guidebooks
Dk. Brown	Collections of papers

Colors have been selected at random and will be augmented as new subjects are published.

Editor: Patricia Allgood

$1269/500