Petrology of Pre-Selma Strata From Core Holes in Western Alabama

By RICHARD E. BERGENBACK

STUDIES OF PRE-SELMA CRETACEOUS CORE SAMPLES FROM THE OUTCROP AREA IN WESTERN ALABAMA

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ABSTRACT

Petrologic studies are reported on four sets of core samples of Coastal Plain sediments from western Alabama. These samples are from the Vick formation of Early(?) Cretaceous age, and from the Coker, Gordo, McShan, and Eutaw, formations of Late Cretaceous age but older than the Selma group.

Grain-size analyses of many small channel samples cut from discrete lithologic units within each formation show that the sediments are dominantly sandy and that the several stratigraphic units may be differentiated in a general way by grain-size distribution and sorting. Thus the Eutaw formation is better sorted than the McShan, although both formations consist of glauconitic sand and silty clay. Random samples, taken from the four formations cannot, however, be relied upon to show these differences.

Thin sections from four rock types in the Vick, Coker, McShan, and Eutaw formations were studied. These types were carbonate-cemented sandstone, chert-cemented sandstone, sand, and silt. The four types consist largely of quartzose mineral and rock fragments that were arbitrarily divided into seven varieties, which were used to deduce the metamorphic and sedimentary source rocks. Point counts show that the proportion of those quartz varieties that are interpreted as being largely of metamorphic origin may be used to differentiate the Vick formation from the others. Relatively large amounts of glauconite distinguish the sediments of the Eutaw and McShan formations from the less glauconitic sediments of the Eoline member of the Coker formation, and from the nonglauconitic sediments of the Vick formation, the upper member of the Coker formation, and the Gordo formation.

INTRODUCTION

In late 1954 the U.S. Geological Survey contracted to have four holes drilled to obtain cores that would provide as complete stratigraphic information as possible about the sequence of Cretaceous sediments underlying the Selma group, which is Late Cretaceous in age. The four holes—the Boykin, Webb, Crawford, and Cleveland holes—are in western Alabama (fig. 1); they penetrated the Vick formation of Early(?) Cretaceous age (Monroe, 1955, and this bulletin) and the Coker, Gordo, McShan, and Eutaw formations of Late

Cretaceous age. Columnar sections that show the positions from which all samples were taken are shown on plate 1.

A petrologic study of the unweathered samples obtained from the cores was made to determine if either grain-size distribution or mineral composition, or both, could be used to differentiate the subsurface Vick, Coker, McShan, and Eutaw formations. The Gordo formation was not studied because it was only partly cored.

All the cores were 2⅛ to 3 inches in diameter, but the percentage of core recovery ranged from 0 to 100 percent. The parts of the holes from which no core was obtained are shown as NC on plate 1. At some places no core was obtained because the attempts were unsuccessful, but at other places no attempt was made to obtain cores, as in loose sand, in the realization that none would have been obtained. Color terms in this report are the visual estimates of the author.

Acknowledgements are due Watson H. Monroe for suggesting this investigation, for supplying the cores, and for making valuable suggestions during the course of the investigation; Arthur J. Gude, 3d, who identified the clay minerals; and C. S. Ross and Charles Milton, who provided descriptions of thin sections of montmorillonitic clays from the Eoline member of the Coker formation.

STRATIGRAPHY

Monroe, Conant, and Eargle (1946), Conant (1946), and Drennen (1953a, 1953b) have described and named the surface formations of pre-Selma sediments of Cretaceous age in western Alabama. Monroe (1955, and this bulletin) has described the lithology and stratigraphy of the four cores analyzed in this investigation, applying the stratigraphic nomenclature of Drennen (1953a). Table 1 shows the stratigraphic relations of the Vick, Coker, Gordo, McShan, and Eutaw formations.

The sediments of the Vick formation are present in the Webb and Cleveland cores, and those of the Coker formation are present in the Boykin and Webb cores. Of the 300-foot total thickness of the Gordo formation, the top 22 feet was penetrated by the Crawford hole, and the bottom 41 and 35 feet by the Boykin and Webb holes, respectively. The Eutaw and McShan formations are present only in the Crawford core. The thicknesses of these units and the drilling record have been reported by Monroe (1955, and this bulletin).

PETROLOGY

SAMPLING

Channel samples for grain-size analyses were taken from discrete lithologic units within each formation (pl. 1). Samples for thin-section study of the composition and distribution of mineral and rock fragments were randomly selected from sandstone, sand, and silt sequences in the Vick, Coker, and Eutaw formations. Lithologic units of clay, silty clay, clayey silt, and sand were spot sampled for identification of clay minerals by X-ray analysis.

GRAIN-SIZE ANALYSES

Grain-size analyses of these relatively unlithified sediments of Cretaceous age were made both by sieving and by the use of a hydrometer (Krumbein and Pettijohn, 1938). No attempt was made to determine particle-size distribution of the clays. The results of the grain-size analyses were plotted in the form of cumulative curves from which sorting coefficient values were obtained. The first and third quartiles (25 percent and 75 percent) were used to determine the sorting coefficients, and the limits set by Trask (1932, p. 70–72) were used to determine the degree of sorting: well sorted is less than 2.5, moderately sorted is from 2.5 to 4.0, and poorly sorted is more than 4.0.

As indicated by Pettijohn (1957, p. 21) little or no agreement has been reached with regard to the names applied to aggregates of sedimentary particles. In this report such an aggregate of particles of differing sizes is designated as sand, silt, or clay if 50 percent or more material by weight falls within the limits prescribed for those size grades. If the particle distribution is such that no size grade contains 50 percent or more material by weight, then the aggregate is named for the size grade containing the largest amount (modal class) of the size distribution. Once the aggregate is named, then such modifying size terms as sandy, silty, or clayey are applied if 10 percent or more of material in these size grades is present.

VICK FORMATION: CLEVELAND CORE HOLE

The Cleveland hole penetrated 70.4 feet of the Vick formation, of which 41.9 feet of core was obtained. The cores consist chiefly of interbedded coarse pebble- and granule-bearing sandstone and unconsolidated sand and silt (pl. 1). Five sandstone beds, which are partly chert cemented and porous, show graded bedding ranging from very coarse sandstone at the base to fine sandstone at the top. The base of each graded sandstone bed contains granules or pebbles of chert and metaquartzite (table 2). Between the sandstone beds are beds of unconsolidated gray and yellow sand and silt.

At the base of the formation is an unconsolidated pebble- and cobble-bearing sand unit which is 6.5 feet thick. Almost no core of this lower unit was recovered, so the unit could not be studied.

Mechanical analyses of the lithified and unconsolidated sediments of these core samples show that very fine to very coarse sand composes 50 percent or more of the material, by weight, in 21 of 22 samples (fig. 2). In addition, the samples contain as much as 16 percent

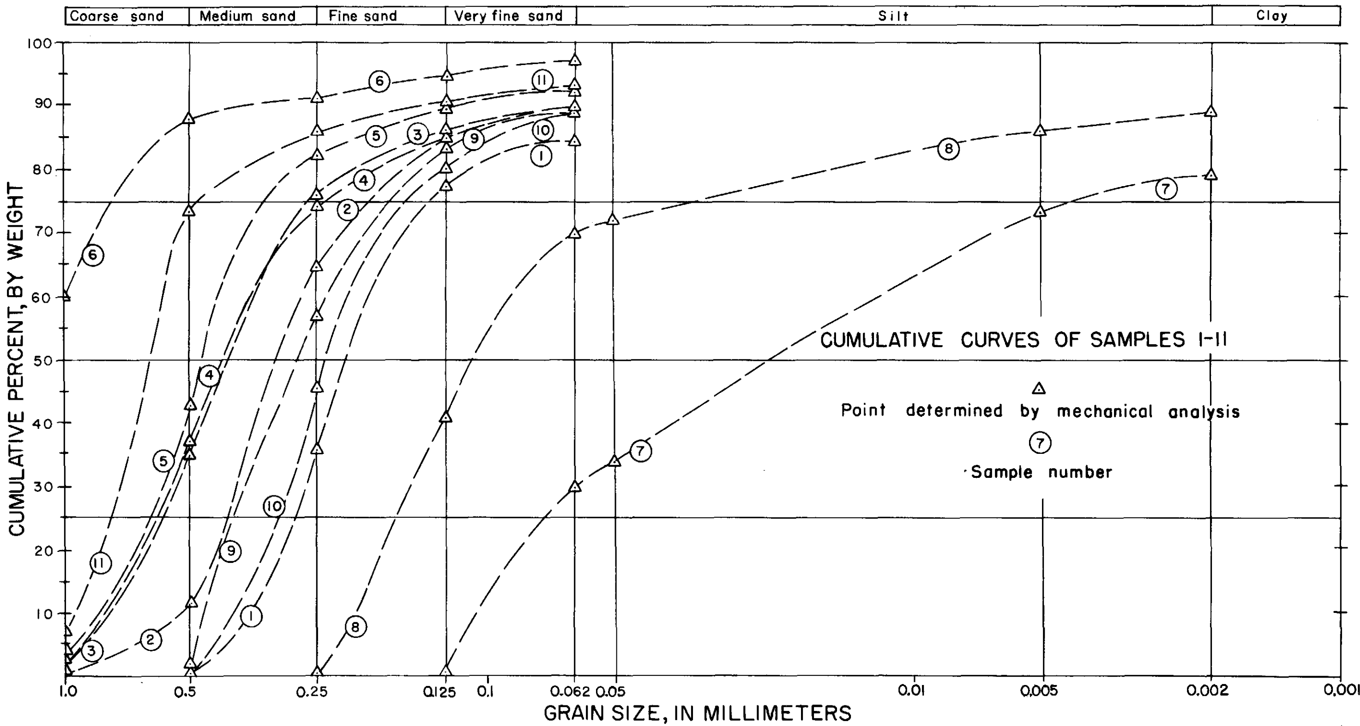
TABLE 1.—*Correlation of stratigraphic units in the*

Drennen (1953b)						Monroe (1955, and this bulletin)					
Series	Group	Formation	Member or bed	Thickness (feet)	Outcrop	Series	Group	Formation	Member or bed	Thickness (feet)	Web core hole
Upper Cretaceous	Selma	Mooreville	Basal sandy [1]	10–25	Sandy chalk or hard chalky sandstone with grains of glauconite, phosphate, and fossil fragments. Contact with Eutaw formation is sharp.	Upper Cretaceous	Selma	Mooreville	Basal sandy		
Upper Cretaceous	Tuscaloosa	McShan and Eutaw undifferentiated		[1] 430±	Clay, sand, and gravelly sand; clay is silty, massive to subfissile, and gray to black, or massive waxy and grayish green; generally rests conformably on Gordo formation. Basal sands are fine to medium, massive to crossbedded.	Upper Cretaceous	Tuscaloosa	Eutaw			
								McShan			
Upper Cretaceous	Tuscaloosa	Gordo		300	Clay, sand, and gravel. Consists locally of 3 units, each of which is composed of heterogeneously bedded clay, sand, and gravelly sand having persistent clay at top and persistent sandy gravel at base. Lies unconformably on Coker formation.	Upper Cretaceous	Tuscaloosa	Gordo		35	Basal sand containing pebbles and cobbles. Contact with Coker formation is sharp.
Upper Cretaceous	Tuscaloosa	Coker	Upper	50–400	Lenticular variegated massive ferruginous clay that is locally sandy and locally contains spherules of siderite. Contact with Eoline member is transitional.	Upper Cretaceous	Tuscaloosa	Coker	Upper	185	Varicolored clay and sand having abundant spherules of siderite, limonite, and hematite in clay. Contact with Coker formation is transitional.
Upper Cretaceous	Tuscaloosa	Coker	Eoline		Lenses of thinly laminated gray clay having partings of rippled glauconitic fine sand, underlain by basal sandy gravel as much as 30 ft thick. Rests conformably on Vick formation and unconformably on rocks of Paleozoic age.	Upper Cretaceous	Tuscaloosa	Coker	Eoline	334	Lignitic clay and lignite bed in upper part, underlain by interbedded glauconitic sand and gray laminated clay, cobbly basal sand. Rests conformably on Vick formation.
Lower (?) Cretaceous		Vick		100	Red and lavender clay underlain by medium to coarse micaceous sand.	Lower (?) Cretaceous		Vick		104	Alternating beds of highly micaceous, fine to coarse red and greenish-gray sand, and red, brown, and gray clay. Basal 20 ft is pebbly and cobbly sand. Rests with sharp contact on shale of probable Paleozoic age.

[1] Information from Monroe, Conant, and Eargle (1946).

core holes with the outcropping units in western Alabama

Monroe (1955, and this bulletin)—Continued					
Thickness (feet)	Boykin core hole	Thickness (feet)	Crawford core hole	Thickness (feet)	Cleveland core hole
		26	Chalky marl containing abundant coarse grains of glauconite and shell fragments, underlain by basal glauconitic, phosphatic, fossiliferous sand and calcareous sandstone.		
		157	Gray laminated clay interbedded with sand containing dark-green coarse glauconite; underlain by basal pebble-bearing sand. Rests with sharp contact on McShan formation.		
		215.5	Gray laminated clay interbedded with sand containing pale-green fine glauconite; underlain by basal medium to coarse sand containing pebbles. Overlies the Gordo fromation disconformably.		
Lower 41	Basal sand containing pebbles and cobbles.	Upper 22	Light-gray clay mottled with red, interbedded with thin-bedded gray sand.		
185	Varicolored clay and sand; abundant spherules of siderite, limonite, and hematite in clay. Contact with Coker formation is transitional.				
291	Thick sequence of alternating beds of laminated gray clay and glauconitic sand having lignitic clay and thin lignite beds in upper part; grades downward into medium to coarse sand that in turn grades downward into medium to coarse basal sand and gravel. Rests with sharp contact on rocks of Paleozoic age.				
				70.4	Sandstone of various degrees of coarseness interbedded with sand, silt, and clay; bottom 10 ft pebbly and cobbly sand. Rests with sharp contact on rocks of Paleozoic age.


Coarse sand
Medium sand
Fine sand
Very fine sand
Silt
Clay
CUMULATIVE PERCENT, BY WEIGHT
GRAIN SIZE, IN MILLIMETERS
1.0
0.5
0.25
0.125
0.1
0.062
0.05
0.01
0.005
0.002
0.001
CUMULATIVE CURVES OF SAMPLES 1-11
Point determined by mechanical analysis
Sample number

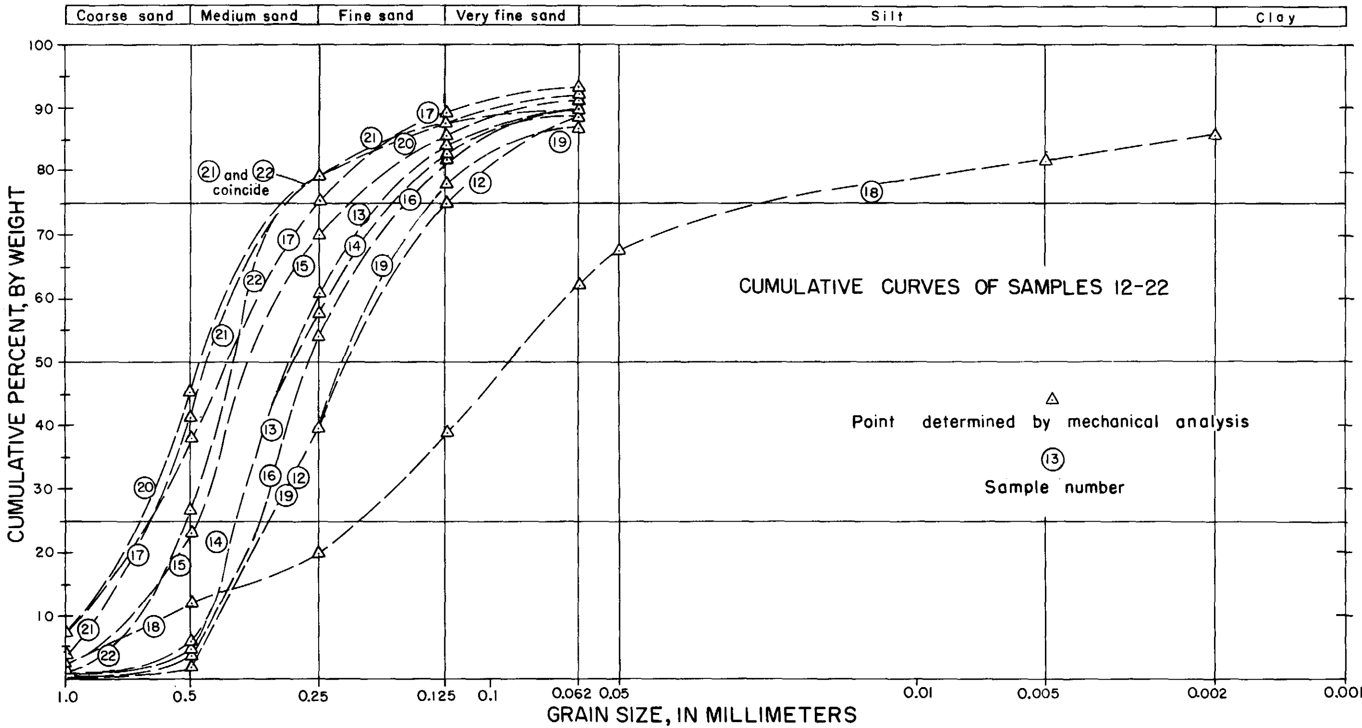


FIGURE 2.—Grain-size analyses of samples of the Vick formation, Cleveland core hole.

TABLE 2.—*Sorting coefficients of samples from the Vick formation*

Vick formation									
Cleveland core samples					Webb core samples				
Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coefficient	Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coefficient
1	0.216	0.292	0.140	1.4	47	0.205	0.300	0.148	1.4
2	.330	.415	.190	1.5	48	.360	.590	.205	1.7
3	.410	.590	.263	1.5	49	.340	.465	.205	1.5
4	.430	.580	.245	1.5	50	.043	.078	.007	3.4
5	.470	.630	.370	1.3	51	.092	.140	.064	1.5
6	1.130	1.450	.770	1.4	52	.088	.110	.038	1.7
7	.026	.084	.004	4.6					
8	.108	.170	.033	2.3					
9	.283	.390	.170	1.5					
10	.243	.310	.157	1.4					
11	.700	.880	.470	1.4					
12	.215	.320	.126	1.6					
13	.300	.380	.177	1.5					
14	.300	.410	.165	1.6					
15	.350	.490	.210	1.5					
16	.260	.345	.163	1.5					
17	.405	.630	.255	1.7					
18	.088	.195	.020	3.1					
19	.215	.335	.135	1.6					
20	.470	.680	.300	1.5					
21	.460	.640	.295	1.5					
22	.410	.520	.310	1.3					

silty and clayey particles, 9 percent granules, and 1 percent pebbles by weight.

VICK FORMATION: WEBB CORE HOLE

The Webb hole, about 17 miles southwest and about 12 miles, downdip from the Cleveland hole, penetrated 104 feet of the Vick formation, from which 27 feet of core was recovered. In contrast with the Cleveland hole, the cores from this hole show no distinct beds of sandstone. Instead, they consist chiefly of unconsolidated well-sorted yellowish- and greenish-gray sand and silty sand, and reddish-brown and grayish-yellow sandy and clayey silt. The sand is very fine to medium grained. Figure 3 and table 2 present the grain size and sorting of these sediments.

Textural analyses of the available core specimens of this formation show that very fine to coarse sand composes 50 percent or more of the material, by weight, in 5 of the 6 samples. The sand locally contains about 1 percent granules.

The basal 32 feet of the Vick formation in this core hole consists largely of pebble- and cobble-bearing sand. No cores were obtained of this basal unit.

COKER FORMATION

The Coker formation consists of the Eoline member in the lower part and of an unnamed upper member. All or nearly all the formation was penetrated by both the Webb and Boykin core holes. The Webb hole penetrated 519 feet of sediments of the formation, of

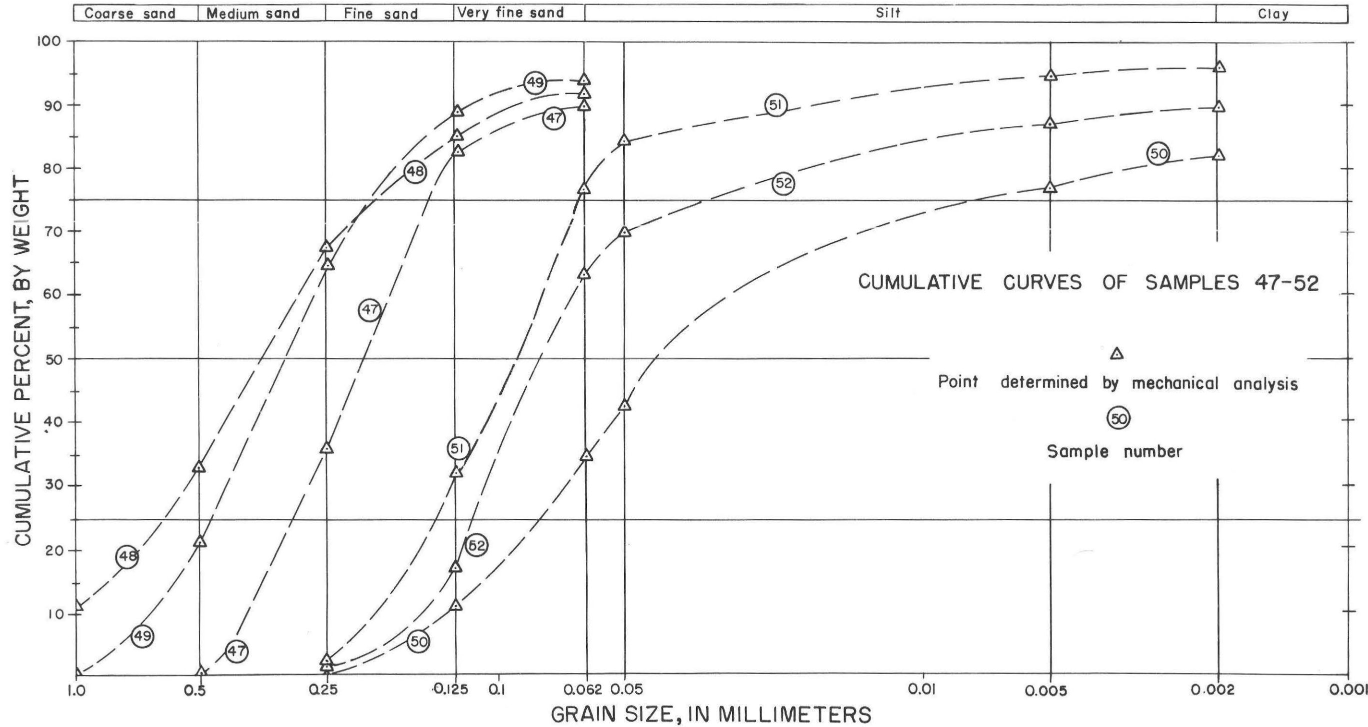


FIGURE 3.—Grain-size analyses of samples of the Vick formation, Webb core hole.

which 334 feet is assigned to the Eoline member and 185 feet to the upper unnamed member. In the Boykin hole the formation is 476 feet thick, of which 291 feet is assigned to the Eoline member and 185 feet to the upper member. Core recovery of the Coker formation from the Webb and Boykin holes was about 45 and 55 percent, respectively. These holes are about 30 miles apart, approximately along the strike of the formation. The Webb hole is in the valley of the Cahaba River, and the Boykin hole is in the valley of the Warrior River.

EOLINE MEMBER

In both the Webb and Boykin test holes the basal part of the Eoline member is a gravelly sand; this sand is 85 feet thick in the Webb hole and 15 feet thick in the Boykin hole (pl. 1). This coarse basal unit is overlain in both holes by a succession of 245 to 250 feet of interbedded and finely laminated gray sandy and clayey silt and silty clay, and fine to medium crossbedded glauconitic silty and clayey sand.

A lignite bed 2 feet thick is present 45 feet below the top of the member in the Webb core hole. Four lignite beds, ranging from 0.5 to 2.1 feet in thickness, are present in the upper 130 feet of the Boykin cores (pl. 1). Fossil mollusks found in several of the cores from the upper 100 feet of the Eoline member in the Webb hole are discussed by Sohl in another part of this bulletin.

The upper contact of the Eoline member is not distinct in the cores from either of the holes. Monroe (1955, p. 15; and this bulletin) has listed criteria for selecting the contact.

Mechanical analyses (figs. 4, 5; table 3) show that sorting in the beds ranges from good to poor. In general, the samples from the Webb cores contain more and better sorted sand than those from the Boykin cores.

Particle-size analyses of samples from the Eoline member of the Coker formation show that very fine to medium sand composes 50 percent or more of the material, by weight, in 38 of 58 samples. An additional 13 samples, 11 of them from the Boykin cores, are classified as sand because the modal class of the size distribution is between 0.062 and 2.0 mm (figs. 4, 5).

UPPER MEMBER

Of the 185-foot thickness of the upper member of the Coker formation in both the Webb and Boykin core holes, 130 feet of core was recovered from the Webb hole and 115 feet from the Boykin hole. This member consists chiefly of interbedded reddish-brown clay, silty clay, sandy and clayey silt, and silty and clayey sand.

TABLE 3.—*Sorting coefficients of samples from the Eoline member of the Coker formation.*

Coker formation, Eoline member									
Boykin core samples					Webb core samples				
Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coef-ficient	Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coef-ficient
22	0.066	0.135	(?)	(?)	20	0.013	0.040	0.0028	3.8
23	.045	.068	0.0127	2.3	21	.170	.197	.135	1.2
24	.044	.080	.009	3.0	22	.042	.087	(?)	(?)
25	.056	.100	(?)	(?)	23	.060	.105	.0185	2.4
26	.032	.073	(?)	(?)	24	.100	.140	.064	1.5
27	.047	.085	(?)	(?)	25	.120	.200	.054	1.9
28	.131	.172	.083	1.4	26	.165	.230	.110	1.4
29	.073	.119	(?)	(?)	27	.075	.104	.0041	5.1
30	.073	.120	(?)	(?)	28	.067	.098	.0062	3.9
31	.064	.100	.0017	7.7	29	.063	.096	.0044	4.7
32	.105	.155	.055	1.7	30	.077	.100	.0585	1.3
33	.165	.190	.130	1.2	31	.203	.265	.165	1.3
34	.041	.083	(?)	(?)	32	.115	.170	.071	1.5
35	.060	.100	.0019	7.3	33	.078	.120	.045	1.6
36	.085	.150	.005	5.5	34	.245	.310	.180	1.3
37	.079	.150	.0255	2.4	35	.063	.112	.0034	5.7
38	.060	.099	.0036	5.2	36	.145	.190	.105	1.4
39	.031	.068	(?)	(?)	37	.155	.243	.084	1.7
40	.042	.079	.0015	7.2	38	.190	.260	.155	1.3
41	.036	.086	(?)	(?)	39	.098	.170	.026	2.6
42	(?)	.0078	(?)	(?)	40	.041	.083	.009	3.0
43	.056	.084	.012	2.6	41	.174	.215	.117	1.4
44	.165	.200	.145	1.2	42	.180	.200	.130	1.2
45	.068	.100	.026	1.9	43	.089	.134	.038	1.9
46	.029	.072	(?)	(?)	44	.105	.165	.062	1.6
47	.051	.095	(?)	(?)	45	.075	.135	.013	3.2
48	.061	.108	.0046	4.8	46	.257	.340	.188	1.3
49	.155	.185	.120	1.2					
50	.068	.100	.024	2.1					
51	.100	.135	.076	1.3					
52	.300	.410	.250	1.3					

The samples of the core recovered from these holes consist largely of interbedded silty and clayey sand, sandy and clayey silt, and a little silty clay—all of which have a wide range in sorting (figs. 6, 7; table 4). Samples from both holes suggest that grain sorting is poorer toward the base of the member. In general, the sediments in the Webb samples are less well sorted than those from the Boykin hole (table 4).

Of the 40 analyses of samples of sediments from the upper member of the Coker formation, 30 contain 50 percent or more material, by weight, in the sand sizes (figs. 6, 7).

GORDO FORMATION

None of the holes penetrated the entire Gordo formation, which is about 300 feet thick. According to Conant and Monroe (1945), the Gordo formation on the outcrop generally consists of interbedded gravel, gravelly sand, sand, and clay with the gravel and gravelly sand decreasing in abundance upward. The Gordo is the upper formation of the Tuscaloosa group.

The Boykin and Webb holes penetrated the lower 41 and 35 feet of the Gordo formation, respectively, and the Crawford hole penetrated

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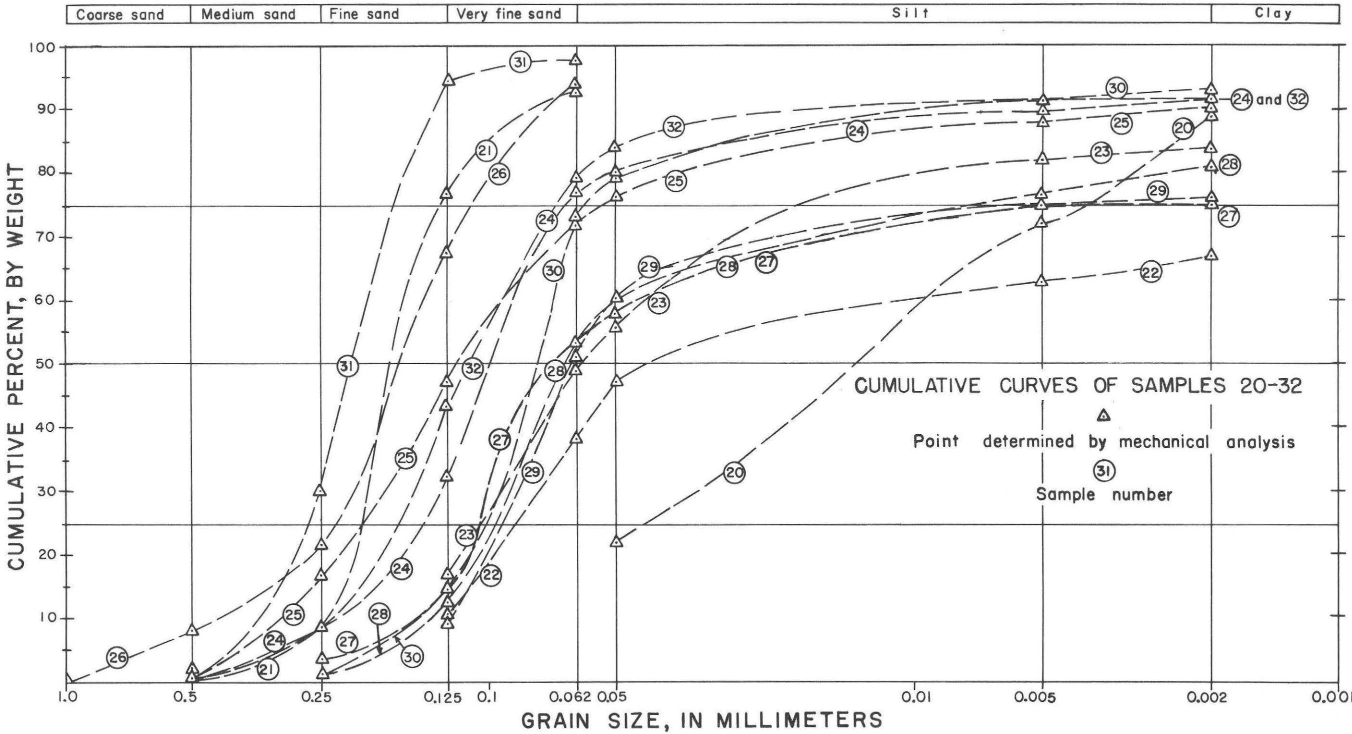

Coarse sand
Medium sand
Fine sand
Very fine sand
Silt
Clay
CUMULATIVE PERCENT, BY WEIGHT
100
90
80
70
60
50
40
30
20
10
1.0
0.5
0.25
0.125
0.1
0.062
0.05
0.01
0.005
0.002
0.001
GRAIN SIZE, IN MILLIMETERS
24 and 32
CUMULATIVE CURVES OF SAMPLES 20-32
Point determined by mechanical analysis
31
Sample number

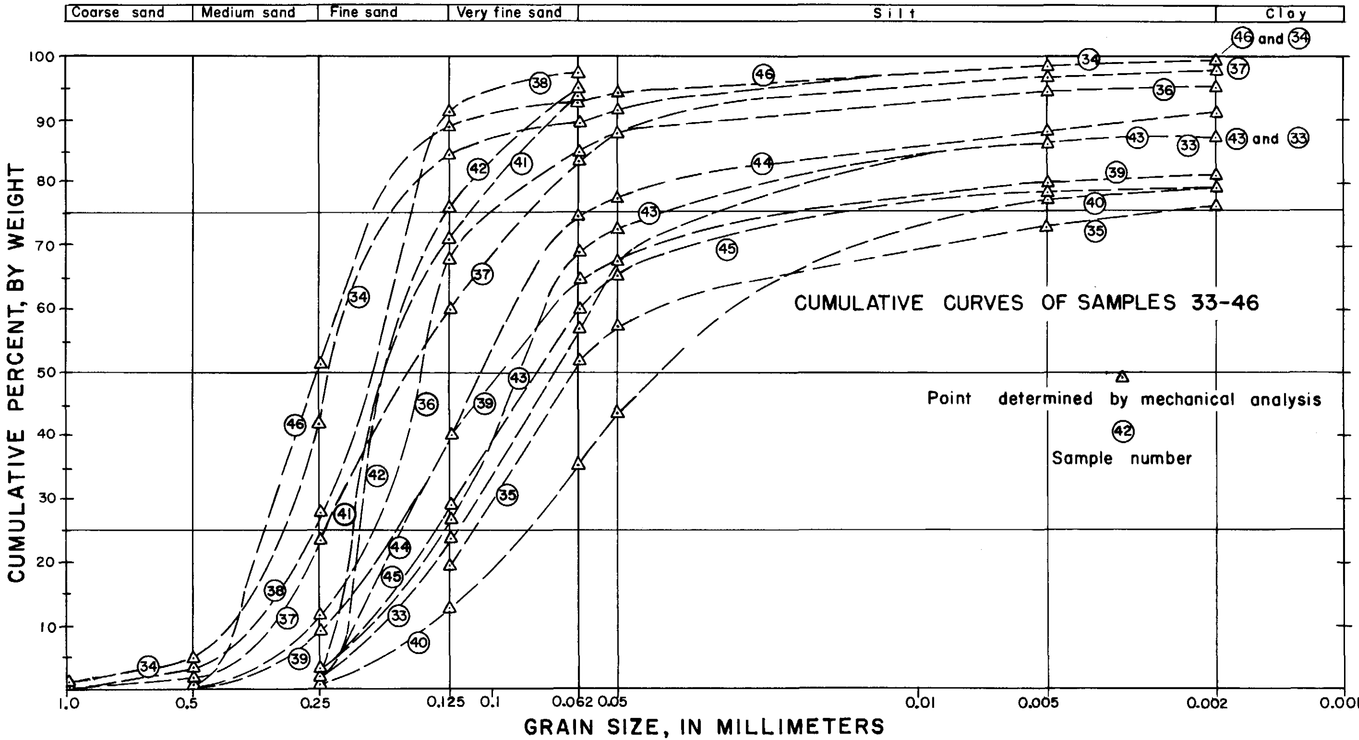
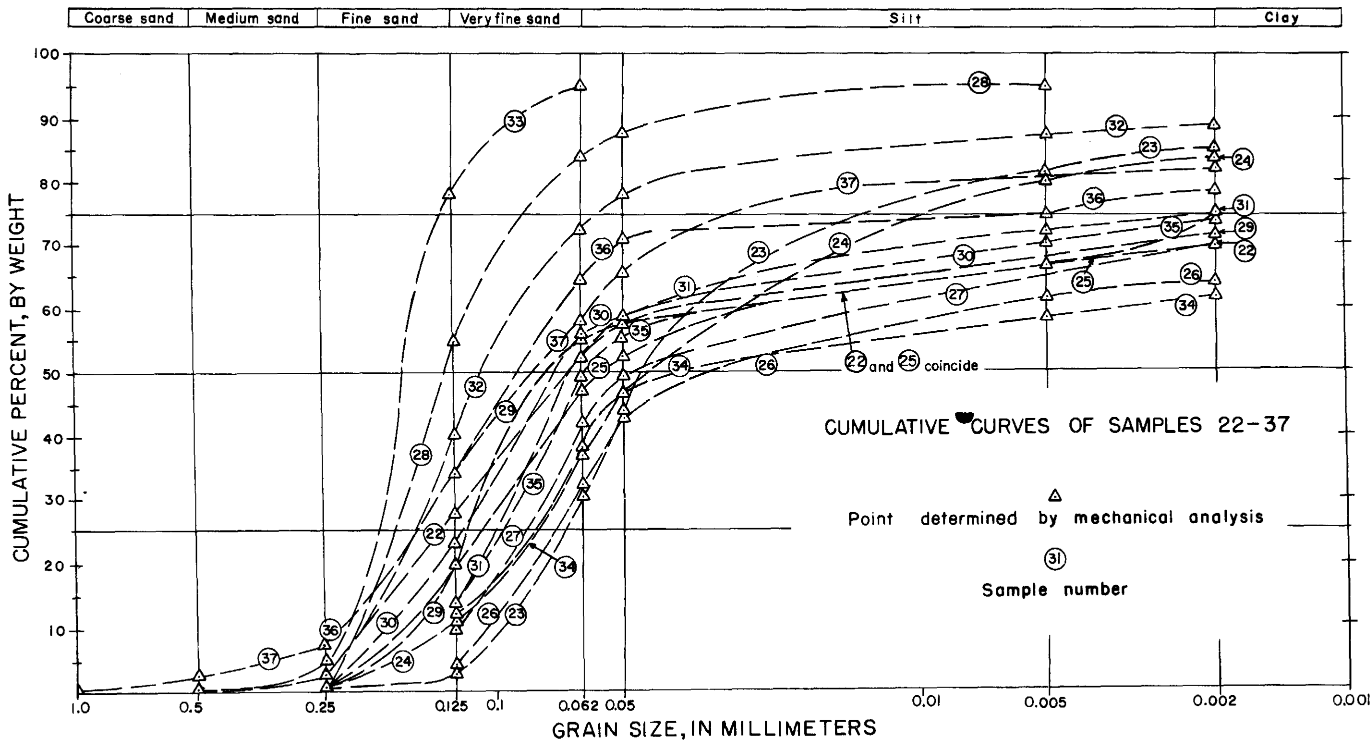


FIGURE 4.—Grain-size analyses of samples of the Eoline member of the Coker formation, Webb core hole.



CUMULATIVE CURVES OF SAMPLES 22-37

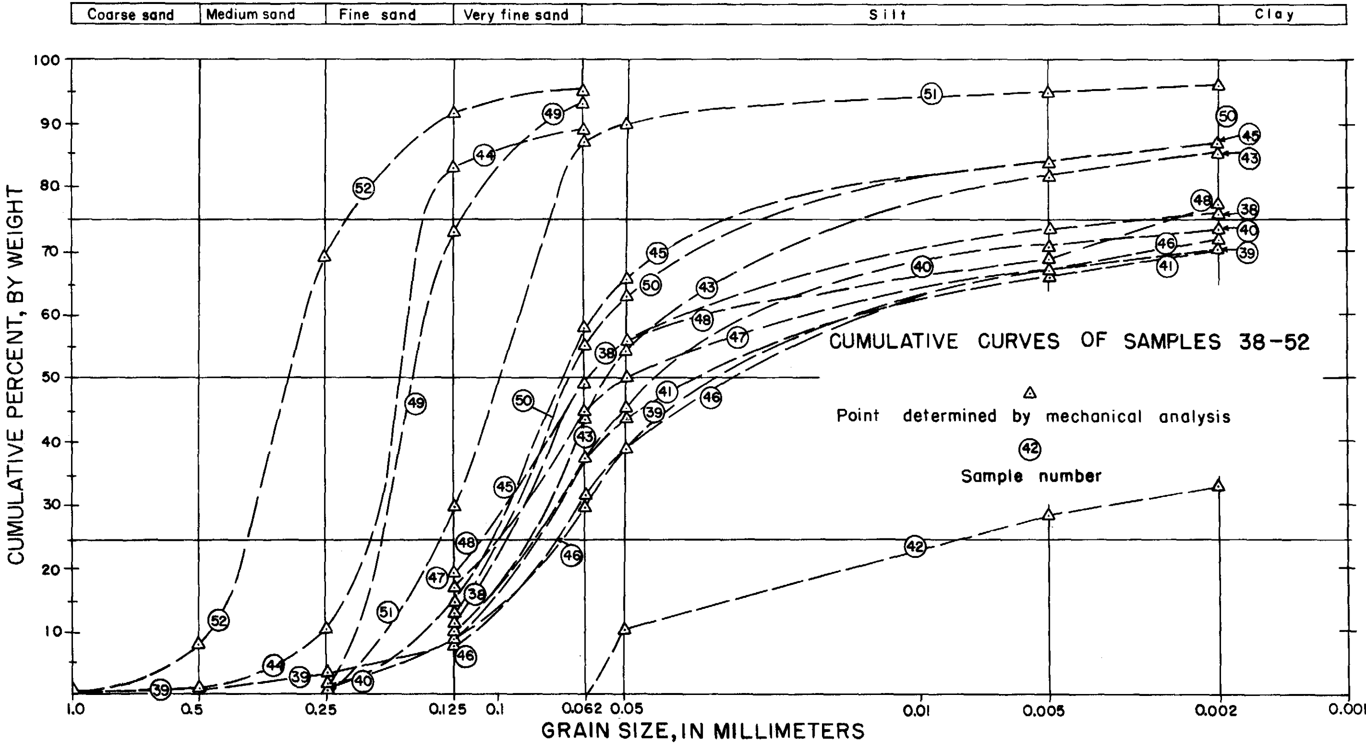
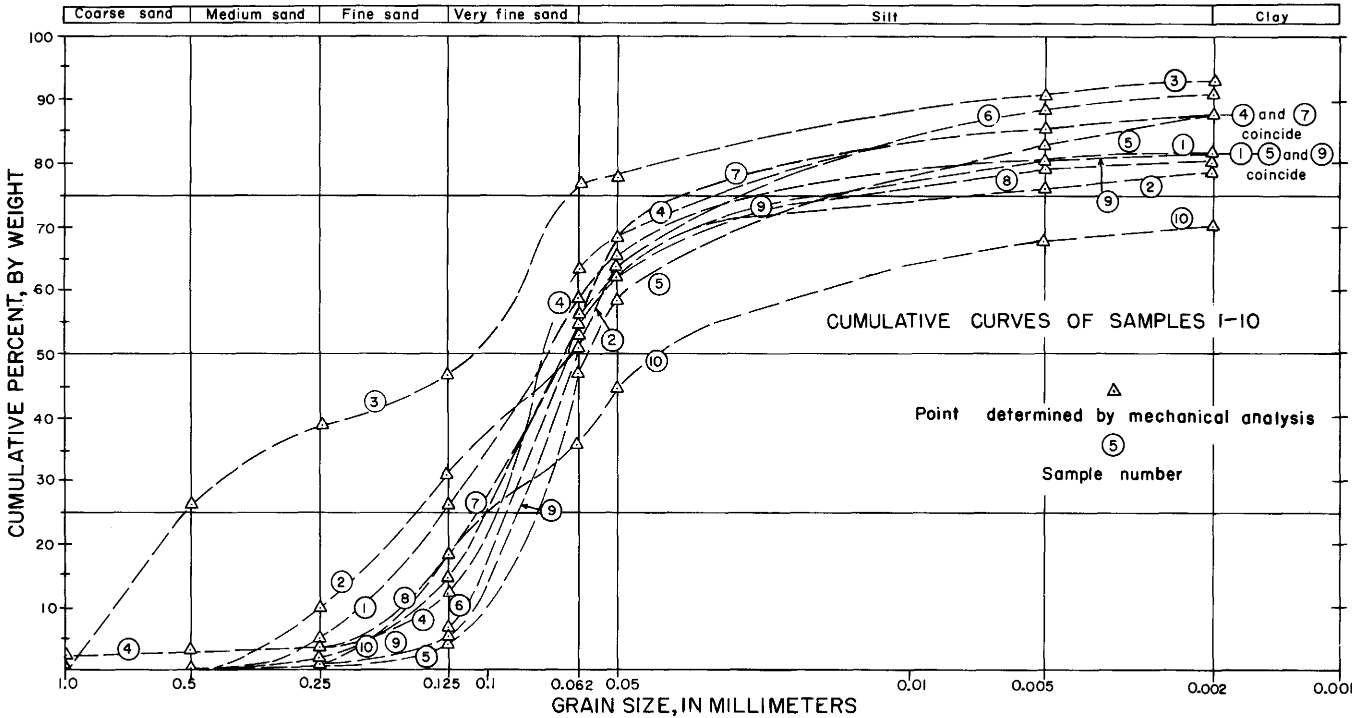


FIGURE 5.—Grain-size analyses of samples of the Eoline member of the Coker formation, Boykin core hole.



Coarse sand
Medium sand
Fine sand
Very fine sand
Silt
Clay
CUMULATIVE PERCENT, BY WEIGHT
GRAIN SIZE, IN MILLIMETERS
1.0
0.5
0.25
0.125
0.1
0.062
0.05
0.01
0.005
0.002
0.001
100
90
80
70
60
50
40
30
20
10
4 and 7 coincide
1 5 and 9 coincide
CUMULATIVE CURVES OF SAMPLES 1-10
Point determined by mechanical analysis
Sample number

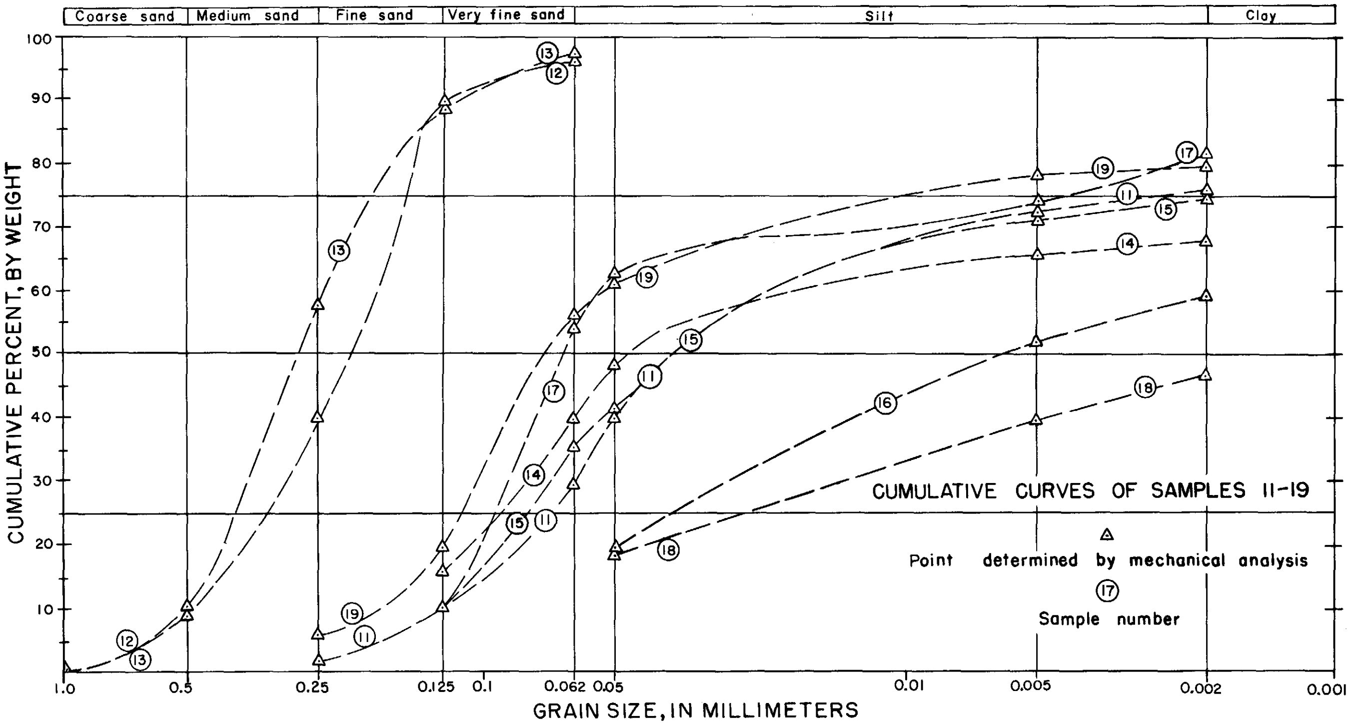
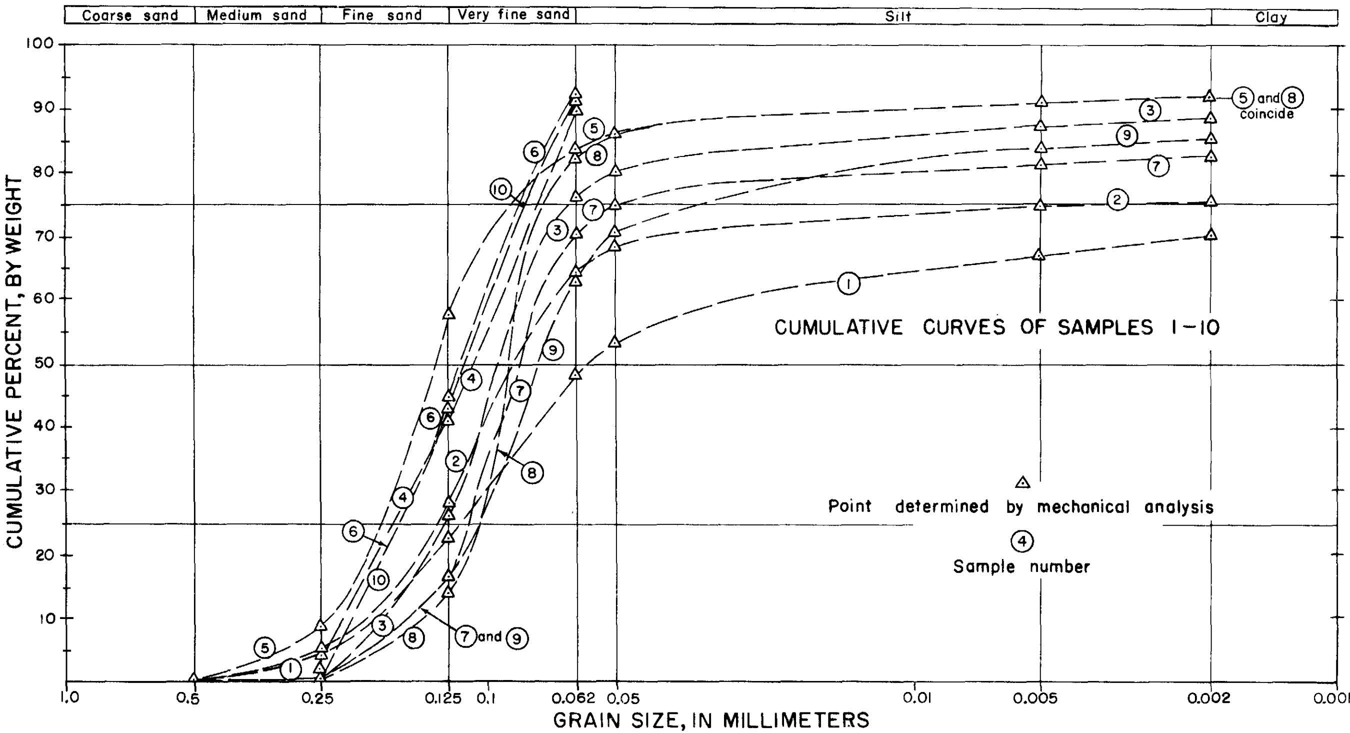


FIGURE 6.—Grain-size analyses of samples of the upper member of the Coker formation, Webb core hole.


Coarse sand
Medium sand
Fine sand
Very fine sand
Silt
Clay
CUMULATIVE PERCENT, BY WEIGHT
GRAIN SIZE, IN MILLIMETERS
1.0
0.5
0.25
0.125
0.1
0.062
0.05
0.01
0.005
0.002
0.001
5 and 8 coincide
7 and 9
CUMULATIVE CURVES OF SAMPLES 1-10
Point determined by mechanical analysis
Sample number

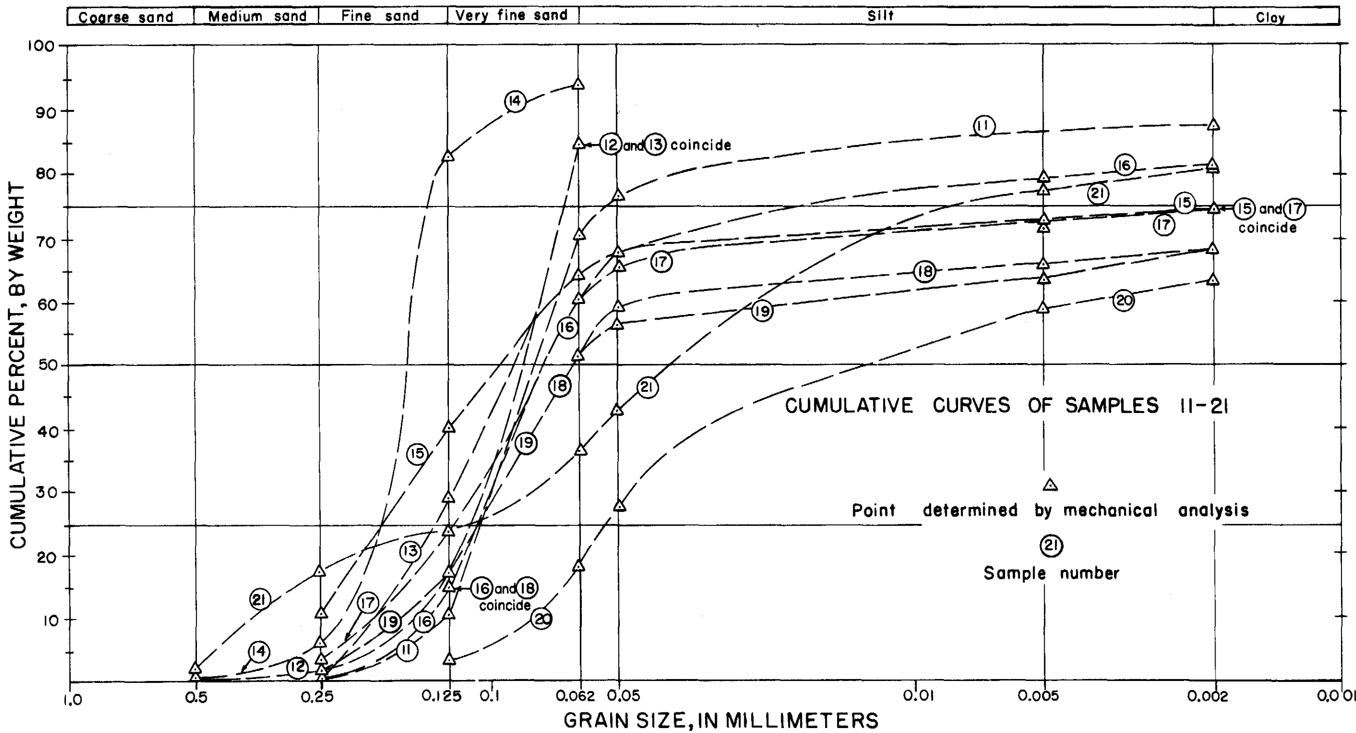


FIGURE 7.—Grain-size analyses of samples of the upper member of the Coker formation, Boykin core hole.

TABLE 4.—*Sorting coefficients of samples from the upper member of the Coker formation*

Coker formation, upper member									
Boykin core samples					Webb core samples				
Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coefficient	Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coefficient
1	0.056	0.116	(?)	(?)	1	0.075	0.130	0.0245	2.4
2	.086	.113	0.002	8.4	2	.062	.150	.0094	4.0
3	.092	.127	.065	1.4	3	.107	.515	.066	2.8
4	.110	.170	.076	1.5	4	.066	.095	.0285	1.8
5	.135	.180	.088	1.4	5	.058	.080	.0165	2.2
6	.115	.170	.084	1.4	6	.076	.095	.030	1.8
7	.083	.110	.049	1.5	7	.067	.113	.00032	5.7
8	.089	.105	.074	1.2	8	.072	.102	.008	3.6
9	.074	.105	.028	1.9	9	.063	.086	.0173	2.2
10	.110	.160	.080	1.4	10	.045	.097	(?)	(?)
11	.082	.105	.053	1.4	11	.0375	.067	.00265	5.0
12	.084	.110	.066	1.3	12	.210	.320	.160	1.4
13	.089	.132	.066	1.4	*13	.280	.390	.185	1.4
14	.160	.180	.142	1.1	14	.047	.092	(?)	(?)
15	.092	.175	(?)	(?)	15	.0365	.080	.0017	6.9
16	.075	.105	.017	2.5	16	.00057	.0255	(?)	(?)
17	.074	.125	(?)	(?)	17	.064	.096	.0046	4.6
18	.064	.102	(?)	(?)	18	.00136	.0235	(?)	(?)
19	.064	.124	(?)	(?)	19	.073	.117	.0107	3.3
20	.014	.053	(?)	(?)					
21	.038	.110	.007	4.0					

*This sample is a check sample against sample 12.

only the upper 22 feet. The core samples from the base of the Gordo consist of gray pebbly to cobbly sand and interbedded gray and orange sandy and clayey silt and silty clay. The samples from the upper part of the formation consist of interbedded red and gray silt and silty clay, and thin beds of gray very fine to fine silty and clayey sand. No grain-size determinations were made on the samples of the Gordo.

McSHAN FORMATION

The entire 216-foot thickness of the McShan formation was penetrated by the Crawford core hole, but only 54 feet of core was recovered. The McShan formation consists of a basal pebbly sand, 30 feet thick, that grades upward into 45 feet of fine to medium glauconitic sand, which in turn is overlain by fine to medium glauconitic, silty sand interbedded with gray sandy and clayey silt.

The McShan formation could not be completely sampled because of the large losses in coring; but, on the basis of the samples taken, the formation is made up of interbedded, well-sorted to poorly sorted granular to pebbly, silty and clayey sand (fig. 8; table 5).

Very fine to medium sand constitutes 50 percent or more material, by weight, in all 15 grain-size analyses (fig. 8). The sand in these 15 samples locally contains as much as 48 percent silt- and clay-sized particles, 8 percent pebbles, and 7 percent granules.

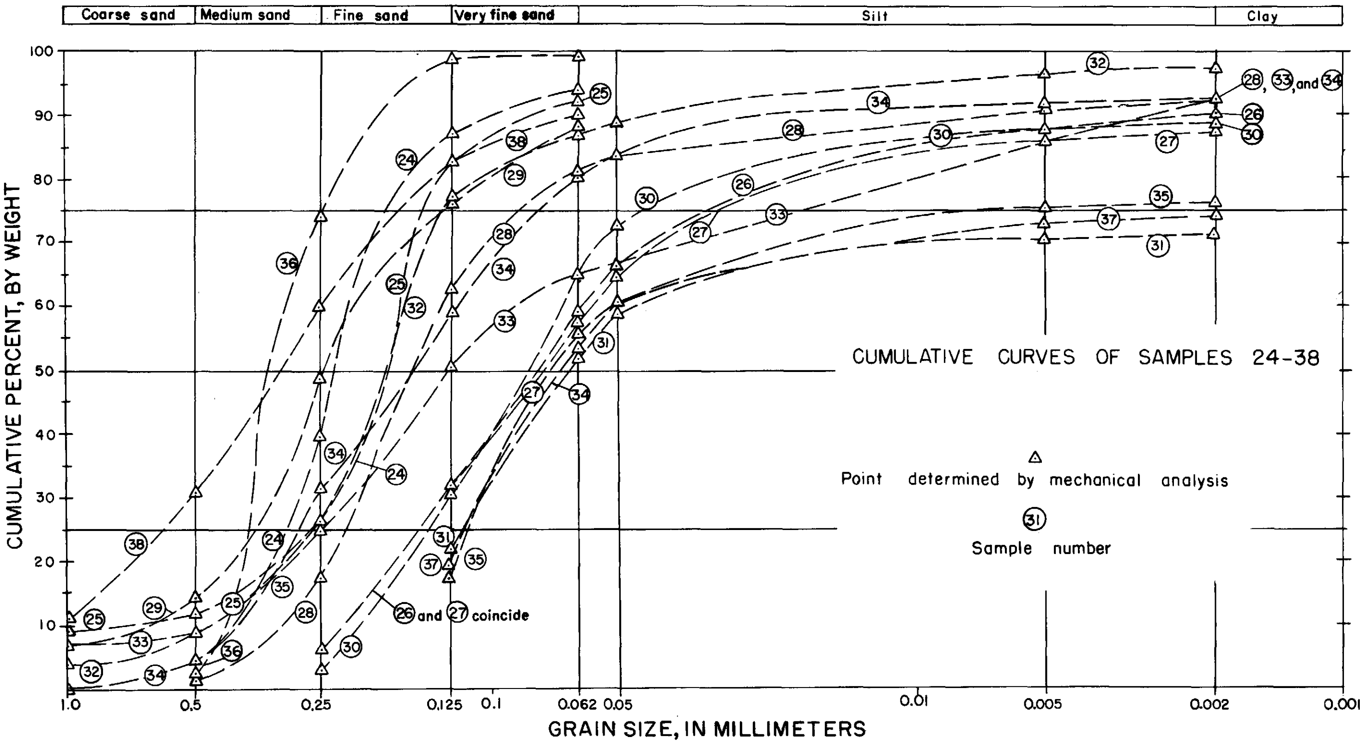


FIGURE 8.—Grain-size analyses of samples of the McShan formation, Crawford core hole.

TABLE 5.—*Sorting coefficients of samples from the Eutaw and McShan formations*

Eutaw formation					McShan formation				
Crawford core samples					Crawford core samples				
Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coefficient	Sample	Median 50 percent	First quartile 25 percent	Third quartile 75 percent	Sorting coefficient
1	0.248	0.385	0.180	1.5	24	0.230	0.300	0.180	1.3
2	.145	.170	.098	1.3	25	.175	.260	.145	1.3
3	.205	.215	.165	1.1	26	.080	.145	.034	2.1
4	.182	.210	.175	1.1	27	.077	.148	.029	2.2
5	.110	.133	.087	1.2	28	.155	.225	.075	1.7
6	.202	.215	.175	1.2	29	.245	.350	.130	1.6
7	.245	.310	.200	1.2	30	.085	.150	.046	1.8
8	.110	.145	.072	1.4	31	.064	.118	(?)	(?)
9	.095	.155	.060	1.6	32	.180	.255	.133	1.4
10	.130	.240	.076	1.8	33	.125	.255	.023	3.3
11	.220	.292	.122	1.5	34	.158	.295	.075	1.9
12	.114	.193	.050	1.9	35	.068	.112	.005	4.7
13	.160	.280	.088	1.8	36	.340	.375	.250	1.2
14	.273	.335	.205	1.3	37	.068	.113	.001	8.9
15	.108	.170	.065	1.6	38	.320	.584	.160	1.9
16	.208	.252	.170	1.2					
17	.078	.114	.060	1.4					
18	.185	.230	.138	1.3					
19	.182	.217	.132	1.3					
20	.203	.215	.165	1.1					
21	.086	.150	.036	2.1					
22	.215	.268	.175	1.2					
23	.305	(?)	.190	(?)					

EUTAW FORMATION

The Eutaw formation was completely penetrated by the Crawford core hole, with a recovery of 90 feet of core from the total thickness of 157 feet. The Eutaw formation is lithologically similar to the underlying McShan formation except that the Eutaw contains more sand, and the glauconite grains are coarser and darker green. Many fossils are present in the upper part of the Eutaw formation.

The samples consist largely of well-sorted sand (fig. 9; table 5) and silty sand. Figure 9 shows that the lower half of the Eutaw formation contains more silt-sized particles than the upper half.

Very fine to medium sand composes 50 percent or more material, by weight, in all 23 textural analyses (fig. 9). Individual samples contain as much as 35 percent silt and clay, 9 percent pebbles, and 4 percent granules. A moderately well sorted, fine to coarse sand at the base of this formation contains as much as 18 percent pebbles and 11 percent granules.

MOOREVILLE CHALK

The Crawford core hole was started in the lower part of the Mooreville chalk of the Selma group and penetrated the lower 26 feet of this formation, from which only 12 feet of core was recovered. The Mooreville chalk consists mainly of argillaceous chalk having abundant coarse dark-green grains of glauconite and abundant fragments of fossils. The basal 3 feet consists of glauconitic, phosphatic, fossiliferous sand and carbonate-cemented sandstone.

SUMMARY OF GRAIN-SIZE ANALYSES

Table 6 is a summary of the grain-size analyses of samples taken from the subsurface Vick, Coker, McShan, and Eutaw formations. On the basis of the available samples it is clear that these sediments are dominantly sandy and that a large part of the sand-sized material is well sorted. In addition, the sediments of the Vick, McShan, and Eutaw formations are better sorted and somewhat coarser than those of the Coker formation. Also, the sediments of the Eutaw formation are better sorted than those of the McShan.

In considering these formational differences in textural sorting and distribution, it must be realized that individual samples taken at random from the four formations cannot be relied upon to show overall differences in grain-size distribution and sorting. The general statements made in this summary are based on a large number of samples taken from only those parts of the four formations that are coherent enough to be recovered when cored.

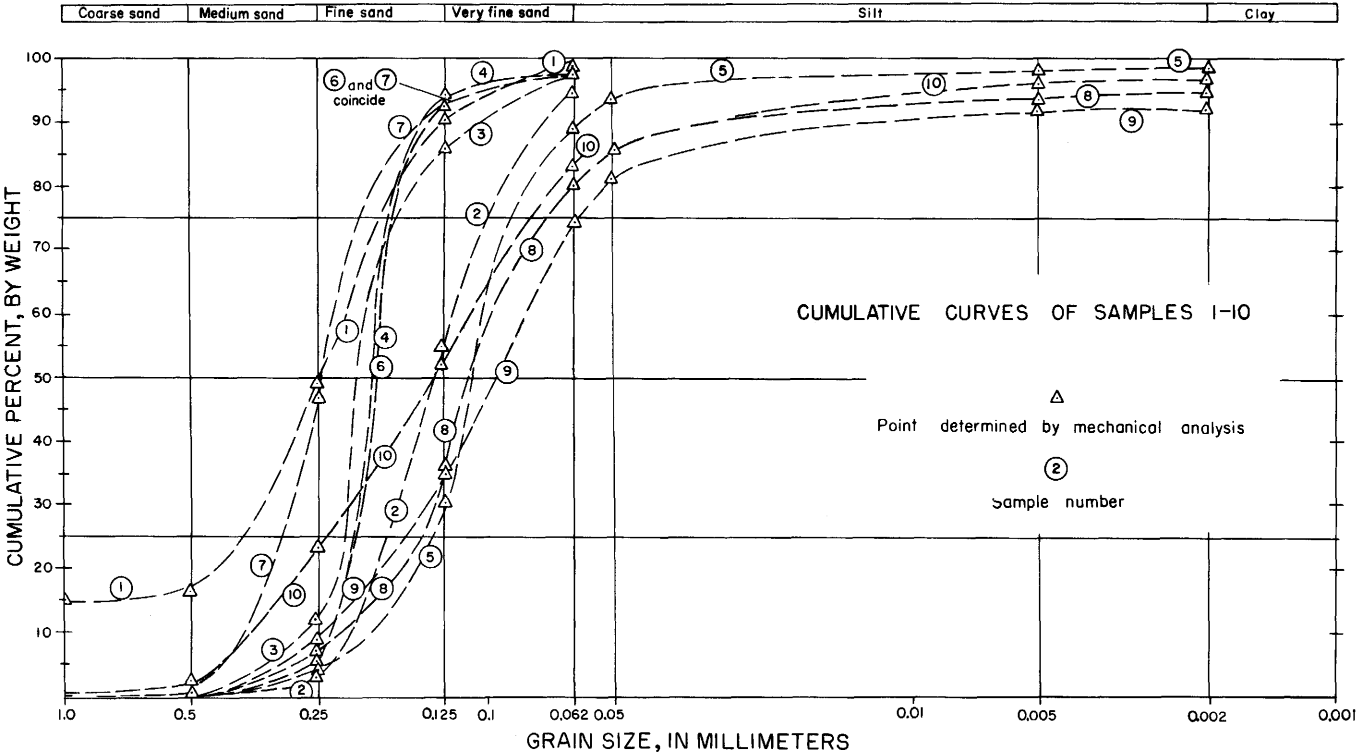
TABLE 6.—*The total number of samples and their sorting coefficients compared with the number of samples containing more than 50 percent sand*

Formation		Core hole	Total number of samples	Sorting coefficients			Number of samples having more than 50 percent sand
				Well sorted less than 2.5	Moderately sorted 2.5 to 4.0	Poorly sorted greater than 4.0	
Eutaw		Crawford	23	22	1	----------	23
McShan		do	15	11	1	[1]1 2	15
Coker	Upper member	Webb	40	7	4	[1]4 4	30
		Boykin		12	2	[1]5 2	
	Eoline member	Webb	58	18	5	[1]1 3	38
		Boykin		11	2	[1]12 6	
Vick		Cleveland	22	20	1	1	21
		Webb	6	5	1	----------	5

[1] Samples from which either the 25 percent or 75 percent quartile was unobtainable.

ROCK-FORMING MATERIALS

Thin sections of carbonate-cemented sandstone, chert-cemented sandstone, and relatively unlithified sand and silt were examined to determine the composition and distribution of rock and mineral fragments. These thin-section studies were made in an effort to differentiate among the formations and to obtain information on which to base interpretations on the probable origin and source areas of the sediments.


Coarse sand
Medium sand
Fine sand
Very fine sand
Silt
Clay
CUMULATIVE PERCENT, BY WEIGHT
GRAIN SIZE, IN MILLIMETERS
1.0
0.5
0.25
0.125
0.1
0.062
0.05
0.01
0.005
0.002
0.001
6 and 7 coincide
CUMULATIVE CURVES OF SAMPLES 1-10
Point determined by mechanical analysis
Sample number

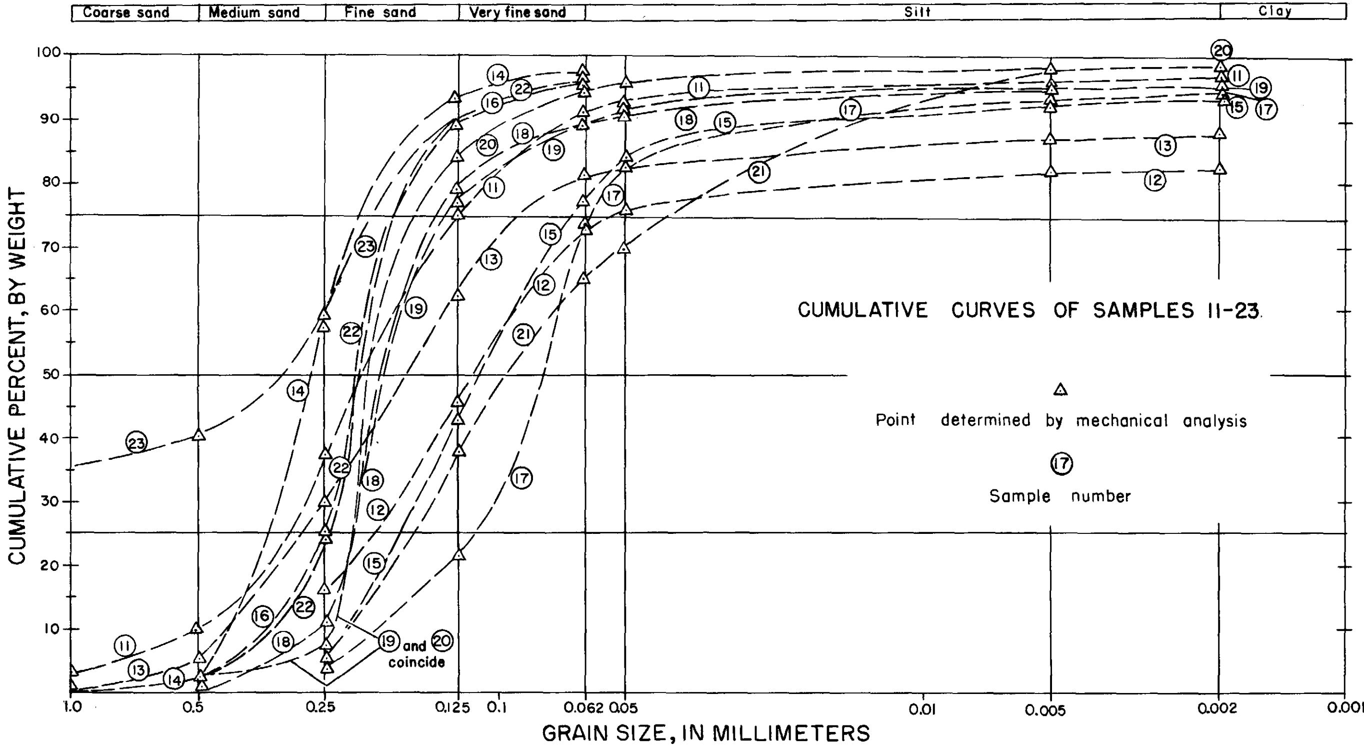


FIGURE 9.—Grain-size analyses of samples of the Eutaw formation, Crawford core hole.

The rock and mineral fragments identified in thin section include: 7 varieties of quartz grains, 3 of which are individual grains and 4 of which are composite grains (rock fragments); orthoclase, microcline, and plagioclase feldspar; muscovite; chlorite; glauconite; tourmaline and traces of a few other minerals; and rock fragments of chert and schist. The matrix or interstitial materials include clay paste and cements of carbonate, chert, and chalcedony.

The 7 varieties of quartz were distinguished by using a procedure modified from that of Folk (1957, p. M–7); 3 varieties of individual quartz grains may be arbitrarily distinguished by the extinction characteristics of the grains under crossed nicols, and 4 varieties of composite quartz grains may be differentiated by the orientation, shape, and interrelations of the particles that make up the grains (fig. 10).

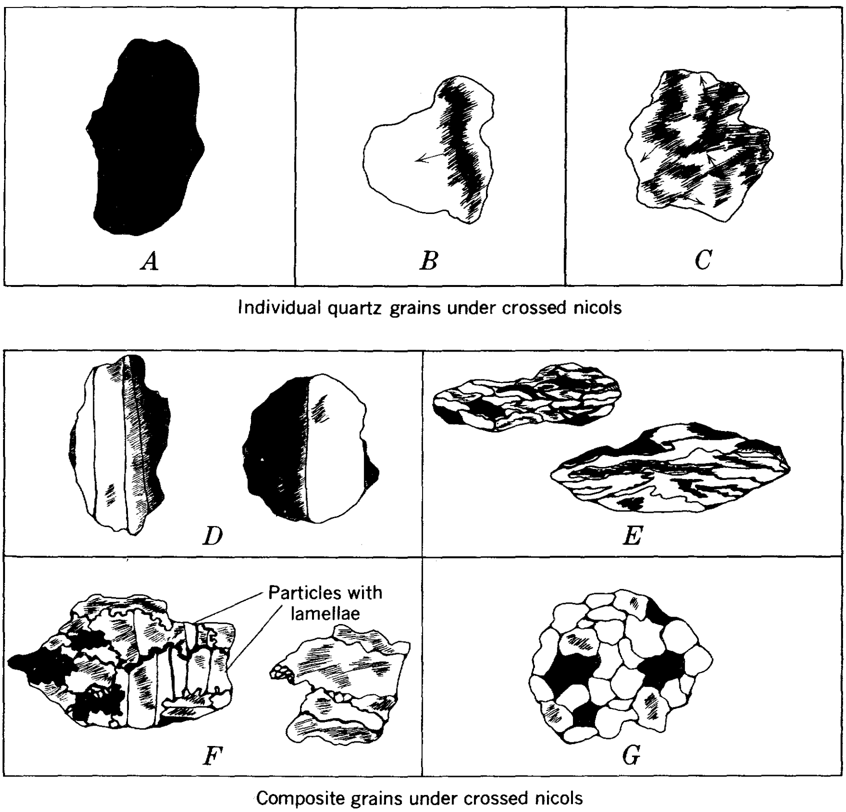


FIGURE 10.—Varieties of quartz in subsurface sediments of the Vick, Coker, McShan, and Eutaw formations. *A*, Unstrained whole grain at extinction at once. *B*, Moderately strained grain has sweeping extinction shadow. *C*, Strongly strained grain has irregular extinction shadows. *D*, Two or more individuals, in subparallel optical orientation, with straight borders. *E*, Particles, in semiparallel optical orientation, with relatively smooth borders. *F*, Two or more individuals, in random optical orientation, with crenulated borders. *G*, Two or more individuals, in random optical orientation, with smooth borders.

The extinction characteristics of the individual quartz grains under crossed nicols are a measure of the degree of straining the grains have undergone. Those that are unstrained to slightly strained are distinguished by an abrupt extinction upon rotation of the microscope stage, generally less than 8°; those that are moderately strained show an extinction shadow that sweeps smoothly across them upon rotation of the microscope stage, generally no more than 20°. The moderately strained quartz grains can be related to the quartz grains that contain well-developed lamellae, which are considered to be a composite quartz variety because in many of them the extinction shadow moves from lamella to lamella, giving a total effect of sweeping smoothly across the grain. Strongly strained quartz grains show extinction shadows that sweep slowly and irregularly across the grain upon rotation of the microscope stage for generally more than 20°.

Composite quartz grains that are aggregates of two or more grains are divisible into four varieties on the basis of optical orientation of constituent particles and the nature of the particle borders. One variety has constituents or lamellae that are in parallel to subparallel optical orientation and have straight borders; these grains are considered to be largely fragments of metaquartz derived from rocks of metamorphic origin such as gneiss, schist, and metaquartzite, but possibly some have come from vein quartz. A second variety has elongate constituents in parallel to semiparallel optical orientation, with smooth to partly crenulated borders; these grains are probably derived from schistose metamorphic rocks. A third variety has mostly unstrained constituents in random optical orientation and with smooth borders; these grains are considered to be derived from orthoquartzitic sedimentary rocks and from recrystallized metamorphic rocks. A fourth variety has particles with crenulated to granulated borders, indications of strong straining within the particles and lamellae, or "bands" within some particles; these grains are probably derived largely from metaquartzites and other relatively coarse-grained metamorphic rocks.

All these rock and mineral fragments are present in the Vick, Coker, McShan, and Eutaw formations, but their abundance in each formation differs somewhat. The abundance of fragments and of the matrix materials was determined by counting one hundred points per thin section. By counting points in increments of 25 and comparing the percent distribution of each increment, these point-count results were found to be accurate within 5 percent.

Thin-section analyses of these sediments showed that the sediments can be grouped for study and comparison as carbonate-cemented sandstone, chert-cemented sandstone, sand, and silt.

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CARBONATE-CEMENTED SANDSTONE

Six carbonate-cemented sandstone beds ranging in thickness from 0.5 to 1.5 feet are represented in samples from the Crawford and Webb core holes. In the Crawford hole, 1 of these sandstone beds is at the base of the Mooreville chalk and 2 are in the Eutaw formation; in the Webb hole 3 sandstone beds are present in a 35-foot zone in the upper half of the Eoline member of the Coker formation (pl. 1).

Composition.—The carbonate-cemented sandstone beds contain the following materials: six varieties of quartz, which is moderately to well sorted and sharply angular to well rounded, with some broken rounded grains; orthoclase, microcline, and plagioclase feldspar; pale-green and pale-tan to opaque, ellipsoidal to almost spherical, well-rounded grains of glauconite; muscovite; chert; and schist. Coarse-grained to granule-sized shell fragments, well-rounded fragments of phosphate (probably collophane) and phosphatized fecal pellets(?) are sparesely present, along with traces of zircon, pink garnet, kyanite, and light-brown tourmaline (table 7).

The mineral and rock fragments are set in a matrix consisting largely of coarsely crystalline calcite whose crystals show the luster mottling (Pettijohn, 1957, p. 653) seen in many carbonate-cemented sandstone beds elsewhere. Many single small crystals of calcite contain as many as 30 fine to medium grains of quartz sand. A thin section of the Mooreville chalk from the Crawford hole (sample 5, table 7) contains 14 percent argillaceous calcilutite admixed with the crystalline calcite material; luster mottling is not well developed in this sample. A thin section of the Eoline member in the Webb core hole (sample 21, table 7) contains small areas having dozens of microscopic pale yellow-brown ovoid bodies and widely scattered quartz grains, all of which are cemented with finely crystalline calcite.

Mode of formation.—The generally well-sorted nature of these sandstone beds and their well-cemented condition suggest that these sediments were winnowed of interstitial silt and clay and the interstices were subsequently filled with carbonate. It is possible that the luster-mottling of the cementing material may have resulted from recrystallization or reorganization of an interstitial lime mud, but the generally well sorted grains and the absence of ghost structures of mineral and rock fragments, other than a few widely scattered unstable plagioclase grains, indicate pore filling by crystalline calcite. Another indication of pore filling is that many grains do not touch any other grain in the thin section. This observed relation could result from a random cut through a well-sorted rock, but many of these grains are far enough from other grains to suggest that the sand grains were forced apart slightly by the crystallization of the carbonate.

TABLE 7.—*Percentage of rock-forming materials in thin sections of carbonate-cemented sandstone (or arenaceous carbonate) from the Coker, Eutaw, and Mooreville formations*

Formation	Sample	Grain size [1]	Rock and mineral fragments																					Matrix			Other
			Quartz varieties									Rock fragments other than quartz varieties				Mineral grains											
			Individual grains				Composite grains (rock fragments)									Feldspar				Other							
			Unstrained	Moderately strained	Strongly strained	Total	Sub-parallel orientation, straight borders	Semi-parallel orientation, moderately smooth borders	Random orientation, smooth borders	Random orientation, crenulated borders	Total	Chert	Schist, undifferentiated	Phosphatic material	Total	Orthoclase	Microcline	Plagioclase	Total	Muscovite	Chlorite	Glauconite	Total	Argillaceous calcilutite	Crystalline carbonate cement	Total	
Crawford core hole																											
Mooreville chalk	5	f-m	25	1	----	26	9	----	----	----	9	----	----	----	----	----	1	----	1	----	----	----	----	14	44	58	[2]6
Crawford core hole																											
Eutaw	7	f-m	29	2	2	33	10	1	----	4	15	----	1	----	1	----	----	----	----	----	----	6	6	----	45	45	----
	10	f-m	22	6	3	31	4	----	----	5	9	2	1	1	4	----	----	----	----	1	----	4	5	----	51	51	----
Webb core hole																											
Eoline member Coker	20	f-m	32	1	1	34	9	2	----	10	21	4	----	----	4	2	----	----	2	----	----	----	----	----	39	39	----
	21	f-m	19	3	----	22	3	----	----	3	6	----	----	----	----	----	1	1	3	----	----	1	1	----	[3]65	65	[4]3
	23	f-m	29	1	1	31	7	----	----	5	12	----	----	----	----	----	3	1	4	----	----	7	7	----	45	45	[5]1

[1] f = fine grained, m = medium grained.
[2] Shell fragments.
[3] Includes patches with tiny ovoid bodies (20 percent).
[4] Shell fragments: this rock may be classified as an arenaceous carbonate.
[5] Detrital garnet.

Cementation rather than reorganization also is suggested by the fact that some grains of glauconite seem to have been forced open, either with no apparent pattern or along apparent lines of cleavage (fig. 11). The same force that apparently forced the sand grains apart may also have broken open some of the glauconite grains.

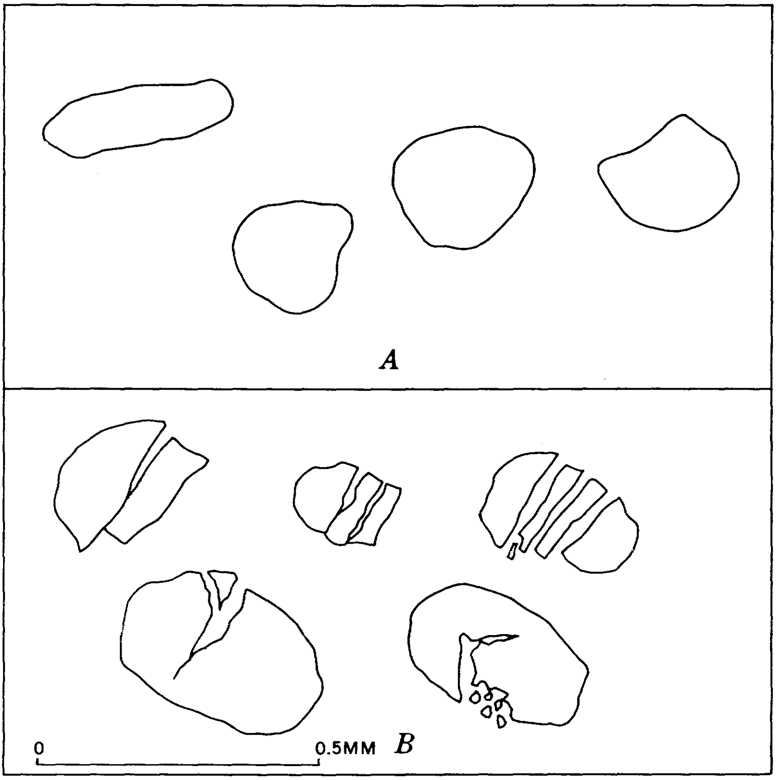

FIGURE 11.—Drawings of glauconite grains in carbonate-cemented sandstone of the Eutaw formation. Sample 10 from the Crawford core hole. Magnification about 75X. *A*, Typical rounded ellipsoidal to nearly spherical and broken rounded grains of glauconite. In carbonate-cemented sandstone. *B*, Typical grains of glauconite that seem to have been split by the force of crystallization during cementation of the carbonate-cemented sandstone.

These observations on glauconite also suggest that the glauconite grains did not form where these well-winnowed sands accumulated, but were probably reworked and transported from a nearby area where they were forming. The fracturing of glauconite in this carbonate-cemented sediment indicates that the grains of glauconite were not nearly as strong as grains of quartz and feldspar; but, because there are well-rounded, unbroken glauconite grains in many of these sediments, it is likely that the sand collected in an area of winnowing currents of only moderate strength, and not in an area of strongly agitated water. The presence of sharply angular shell fragments supports this interpretation.

The tiny pale yellow-brown ovoid bodies cemented by finely crystalline calcite that form patches in the carbonate-cemented sandstone beds of sample 21 in the Eoline member are probably phosphatized fecal pellets of some marine organism.

Provenance.—The presence of several varieties of quartz in each of these carbonate-cemented sandstone beds suggests a multiple source for the sediments. Further, the mixture of sharply angular, well-rounded, and broken rounded mineral grains of approximately the same size also suggests that the material was derived from terranes underlain by both crystalline and sedimentary rocks.

Some of the unstrained and moderately strained quartz grains and most of the feldspars were probably derived from igneous rocks, and possibly also some from recrystallized metamorphic rocks. Most of the strongly strained quartz, quartz grains with lamellae, schistose quartz aggregates, and other composite grains, along with trace amounts of garnet and kyanite, were probably derived from metamorphic rocks. The rounded and broken rounded grains of all the quartz varieties, along with rounded chert grains, trace amounts of rounded tourmaline and zircon. and well-rounded phosphatic fragments indicate a source underlain by sedimentary rocks.

The fragments of fossils may represent animals that lived at the site of deposition, or they may have been brought in from nearby. It is likely that some or much of the glauconite was derived from neighboring areas.

The phosphatic grains probably were derived from phosphatic rocks inasmuch as silt-sized angular grains of quartz are occluded in these fragments, and veinlets of phosphate crosscut phosphatic grains.

CHERT-CEMENTED SANDSTONE

Five partly chert-cemented and somewhat porous sandstone beds of the Vick formation were encountered in the Cleveland core hole and two were encountered in the upper part of the Vick formation in the Webb core hole (pl. 1).

Composition.—The principal constituents of the chert-cemented sandstone beds are: fine-grained to very coarse grained, subrounded to well-rounded quartz of the seven previously described varieties; orthoclase, microcline, and plagioclase feldspar; chert; schist; and muscovite (table 8). These constituents are set in chert and chalcedonic cement.

Texture and the mode of formation.—The five sandstone units of the Cleveland core hole samples show moderately well developed graded bedding, generally grading upward from a well-sorted coarse to very

TABLE 8.—*Percentage of rock-forming materials in thin sections of chert-cemented sandstones from the Vick formation*

Formation	Sample	Grain size [1]	Rock and mineral fragments																		Matrix			
			Quartz varieties									Rock fragments other than quartz varieties			Mineral grains						Cement			
			Individual grains				Composite grains (rock fragments)								Feldspar				Other					
			Unstrained	Moderately strained	Strongly strained	Total	Subparallel orientation, straight borders	Semiparallel orientation, moderately smooth borders	Random orientation, smooth borders	Random orientation, crenulated borders	Total	Chert	Schist, undifferentiated	Total	Orthoclase	Microcline	Plagioclase	Total	Muscovite	Total	Chert	Chalcedony	Total	Voids
Cleveland core hole																								
Vick	1	f-m	19	10	11	40	15	----	2	10	27	1	1	2	----	1	1	2	8	8	10	----	10	11
	2	m	27	1	6	34	18	3	----	23	44	----	----	----	1	1	2	4	7	7	6	1	7	4
	3	m-c	8	----	11	19	22	6	----	24	52	----	----	----	3	1	1	5	4	4	9	3	12	8
	4	m-c	14	2	3	19	28	----	1	28	57	1	----	1	1	1	----	2	4	4	10	----	10	7
	5	m-c	16	4	3	23	19	1	3	25	48	3	----	3	1	1	----	2	1	1	8	----	8	15
	6	c-vc	8	4	6	18	13	----	1	30	44	7	----	7	----	1	----	1	----	----	23	----	23	7
	7	f-m	22	5	4	31	22	4	2	19	47	----	----	----	2	----	----	2	2	2	9	----	9	9
	8	f-m	14	4	3	21	17	1	----	25	43	1	----	1	1	----	1	2	2	2	10	----	10	21
	9	c	16	8	7	31	18	1	----	24	43	----	----	----	----	----	1	1	2	2	6	----	6	17
	10	f-m	11	9	2	22	21	5	----	22	48	----	----	----	----	----	----	----	2	2	14	----	14	14
	11	f-m	7	1	5	13	18	1	1	23	43	2	----	2	1	----	3	4	14	14	16	----	16	8
	12	f-m	13	6	3	22	22	4	1	12	39	3	----	3	----	----	1	1	11	11	23	----	23	1
	13	f-m	21	4	1	26	19	5	1	18	43	1	----	1	1	----	----	1	9	9	14	----	14	6
	14	m-c	17	4	2	23	29	4	1	18	52	----	1	1	1	----	----	1	4	4	8	----	8	11
	15	f-m	13	10	2	25	12	7	1	21	41	2	----	2	----	----	----	----	2	2	11	----	11	19
	16	m-c	22	1	1	24	17	4	1	18	40	----	----	----	----	1	----	1	5	5	25	----	25	5
	17	m-c	17	5	6	28	18	1	----	22	41	1	----	1	----	----	----	----	2	2	22	----	22	6
	18	m-c	18	6	1	25	20	3	----	18	41	----	1	1	----	----	----	----	4	4	24	----	24	5
	19	c	12	----	1	13	13	6	----	23	42	----	1	1	----	2	1	3	16	16	7	----	7	18
Webb core hole																								
Vick	29	f-m	29	5	3	37	11	11	----	3	25	3	4	7	----	----	1	1	1	1	25	----	25	4
	30	m	24	3	3	30	17	9	----	8	34	----	4	4	----	1	----	1	[2] 8	8	20	----	20	3

[1] f=fine-grained; m, medium-grained; c, coarse-grained.
[2] Includes 3 percent chlorite flakes.

coarse sand to a well-sorted fine to medium sand. In places the coarser sand contains as much as 1 percent pebbles and 9 percent granules. These sandstone beds have been winnowed of all but minor amounts (maximum of 16 percent) of silty and clayey material. With the exception of small amounts of feldspar (5 percent in one sample), these sandstone beds are composed largely of chemically and mechanically stable mineral and rock fragments.

The graded bedding of five units that are stratigraphically near each other suggests deposition by currents of increasing and decreasing velocity, such as characterize streams. This and the stable nature of the clastic material suggest reworking of material that was derived chiefly from a peneplaned area. The sediments of the Vick formation in the Webb core hole are well bedded and sorted and are thought to be marine.

Provenance.—Some of the unstrained and moderately strained quartz, and most of the feldspar, probably came from igneous rocks or recrystallized metamorphic rocks. It is likely that metamorphic rocks contributed large amounts of the strongly strained quartz grains, quartz grains with lamellae, schistose quartz, fragments of schist, and quartz grains interpreted as derived largely from metaquartzite. Sedimentary rocks probably contributed the rounded chert grains and many of the varieties of well-rounded quartz that were derived originally from igneous and metamorphic rocks.

The chert cement was probably brought to these sediments penecontemporaneously from a highly weathered peneplaned area as soluble silica. Supporting this belief is the fact that the sand grains do not seem to be compressed, hence pressure solution between chert and quartz grains within the beds is not indicated as a source of silica.

The associated reddish-brown sandy and clayey silt beds in the Vick formation probably represent reworked iron-stained clayey and silty soils.

SAND

The bulk of the pre-Selma sediments of Late Cretaceous age consist of very fine to medium sand, though some samples contain as much as 59 percent silty and clayey material. The sediments in the upper member of the Coker formation, in both the Webb and the Boykin core samples, are largely red and brown stained, and the higher sand beds contain spherulites of siderite. The sand beds of the Eoline member of the Coker formation and of the McShan and Eutaw formations are glauconitic.

Composition.—The sand grades vertically into silty and clayey sand, sandy and clayey silt, and sandy and silty clay. The chief constituents of the sand beds are: moderately well sorted to well-sorted, very fine to medium, mostly subangular grains of the seven varieties of quartz; three types of feldspar; chert; schist; pale-green and pale-tan to opaque, varishaped but usually ellipsoidal to nearly spherical grains of glauconite; and flakes of muscovite and chlorite. More rarely, grains of sandstone, claystone, spherulitic chalcedony, pink garnet, zircon, and tourmaline are present.

These rock and mineral fragments generally are set in a matrix of clay paste consisting of finely divided flakes and shreds of colorless to pale-green micaceous clay minerals and tiny bits of quartz (table 9). Many minute, opaque, somewhat rounded bodies are present in the interstitial clay paste of the sand, especially in the red- and brown-stained sands; these grains may be incipient, authigenic siderite.

Mode of formation.—The glauconite-bearing sand is presumed to be of marine origin, though the lignite beds adjacent to sand beds in the upper part of the Eoline member of the Coker formation suggest that swampy and lagoonal conditions must have existed at some places. The large amount of interstitial clay paste suggests a lack of winnowing currents, a condition which also suggests swampy backwaters in marginal marine and shallow marine estuaries and lagoons. The thin well-winnowed carbonate-cemented sandstone beds in the Eoline member of the Coker formation and in the Eutaw formation suggest brief incursions of very shallow, more agitated marine waters. The combination of these relations indicates an area of marginal marine and shallow marine accumulation.

The red-bed sequence in the upper member of the Coker formation may indicate rapid sedimentation of red-stained terrestrial materials into lagoonal areas. These red materials may have been soils swept off a landward area that was undergoing uplift. With increased uplift, erosion would have exposed unweathered bedrock in the source area, thus accounting for the abundance of pebbly sand in the overlying Gordo formation.

Provenance.—The large amount of very fine to medium, moderately sorted to well sorted, largely subangular sand in these sediments suggests derivation from preexisting relatively fine grained rocks. The abundance of types of quartz (tables 7–9) interpreted as metamorphic in origin suggests a source area or areas underlain largely by metamorphic rocks. The abundant muscovite and lesser amounts of chlorite flakes, grains of schist, pink garnet, kyanite, and the abundant micaceous materials of the clay paste also indicate a major contribution from fine-grained metamorphic rocks. It is likely that sedimentary rocks also contributed to these sediments, because of the presence of some well-rounded quartz grains, chert grains, and the trace amounts of rounded zircon and tourmaline grains. Some of the clay paste material may also have been derived from clay-rich sedimentary rocks.

SILT

On the basis of mechanical analyses, the silt in the sediments of pre-Selma Cretaceous age was found to be less abundant than the sand (table 10). The silt is randomly distributed in the Vick, Coker, McShan, and Eutaw formations, and is similar in composition to the sand. The large amount of interstitial clay paste suggests that the silt accumulated in quiet water and very likely was derived from virtually the same sources as the sand. Owing to the fineness of the silt, quartz grains were the only readily identifiable constituents.

MARL

Four samples of the marly sediments at the base of the Mooreville chalk in the Crawford core hole (pl. 1) were examined in thin section. These samples were taken from what is probably a transition zone between the detrital quartz-sand sediments of the Eutaw formation and the highly marly rocks of the overlying Mooreville chalk.

Table 11 shows the results of 100 point counts made on each slide. It will be noted that the lower samples, Nos. 3 and 4, contain relatively large amounts of glauconite, detrital quartz fragments, and some finely crystalline carbonate. Samples 1 and 2 consist largely of argillaceous calcilutite and carbonate-filled Foraminifera that are largely pelagic types (E. R. Applin, written communication, Sept. 27, 1957). The marly composition of most of the Mooreville samples, with only the finest of land-derived material and pelagic types of Foraminifera, suggests either a shallow-water deposit with relatively little terrigenous material or a protracted incursion of much deeper, far-from-shore marine waters, as contrasted to the shallow-water and near-shore marine conditions at the time the sediments of the Eutaw formation were deposited.

DISTRIBUTION OF ROCK AND MINERAL FRAGMENTS

Tables 7 to 10 show the percentages of rock and mineral fragments, matrix materials, and voids in the four types of sediment of pre-Selma age that have been discussed. Table 12 shows the average percentages of the rock and mineral fragments in those four types of sediment in the several formations. All of these tables were examined for significant differences in the composition and proportion of rock and mineral varieties in the different formations.

Only minor differences were noted; for example, table 7 shows a somewhat greater amount of feldspar in the Eoline member of the Coker formation than in the other units compared. However, table 10 shows this to be true only among the quantitatively insignificant carbonate-cemented sandstone beds. Table 9 shows that no glauconite was observed in samples from the upper member of the Coker formation, but Drennen (1953a, p. 535) reported that sparse grains

TABLE 9.—*Rock-forming materials, percentage in thin sections, Coker, McShan, and Eutaw formations—44*

Formation	Sample	Grain size [1]	Rock and mineral fragments																				Matrix			Other	Voids
			Quartz varieties									Rock fragments other than quartz varieties			Mineral grains												
			Individual grains				Composite grains (rock fragments)								Feldspar				Other								
			Unstrained	Moderately strained	Strongly strained	Total	Subparallel orientation, straight borders	Semiparallel orientation, moderately smooth borders	Random orientation, smooth borders	Random orientation, crenulated borders	Total	Chert	Schist, undifferentiated	Total	Orthoclase	Microcline	Plagioclase	Total	Muscovite	Chlorite	Glauconite	Total	Clay paste	Crystalline carbonate cement	Total		
Crawford core hole																											
Eutaw	6	f	27	12	3	42	6	1	----	4	11	----	3	3	----	1	1	2	5	----	14	19	12	----	12	[2] 1	10
	8	f-m	19	8	3	30	12	1	----	8	21	1	1	2	----	2	3	5	1	----	20	21	14	----	14	----	7
McShan	11	f-m	24	6	2	32	6	----	1	3	10	----	----	----	----	2	----	2	9	4	12	25	31	----	31	----	----
Boykin core hole																											
Coker, upper member	1	vf	23	13	3	39	11	5	----	2	18	7	----	7	2	1	1	4	9	----	----	9	[3] 19	----	21	[4] 2	2
	3	f	26	8	3	37	12	2	1	7	22	3	5	8	----	1	1	2	5	----	----	5	1	----	1	[5] 4	21
Eoline member	5	vf-f	20	17	9	46	5	1	----	5	11	1	2	3	1	----	1	2	10	----	----	10	25	----	25	[6] 1	2
	6	vf-f	16	18	2	36	2	----	----	4	6	2	2	4	2	----	----	2	2	----	2	4	48	----	48	----	----
	13	m	27	5	5	37	10	----	----	21	31	2	----	2	1	----	3	4	1	----	----	1	9	----	9	[7] 1	15
	14	m	12	9	8	29	14	----	----	19	33	3	----	3	3	1	1	5	----	----	----	----	14	----	14	----	16

Webb core hole [8, 9]

Coker, upper member	2	vf–f	25	6	9	40	3	----	1	1	5	----	----	----	----	----	----	----	5	----	----	5	[3] 50	----	50	----	----
	3	vf–f	20	6	4	30	6	----	----	4	10	----	----	----	----	----	----	----	1	----	----	1	[3] 59	----	59	----	----
	4	vf	19	11	8	38	5	----	----	1	6	----	3	3	----	----	1	1	5	1	----	6	[3] 18	----	46	[4] 28	----
	5	vf	28	18	6	52	----	----	----	----	----	----	----	----	----	2	----	2	8	4	----	12	[3] 35	----	35	[10] 1	----
	6	vf	23	14	8	45	12	1	----	4	17	2	1	3	----	----	----	----	9	----	----	9	[3] 19	----	19	----	7
	7	vf	26	26	2	54	8	----	----	2	10	----	4	4	----	----	----	----	6	----	----	6	[3] 26	----	26	----	----
	8	vf	18	20	10	48	4	----	----	4	8	4	----	4	----	----	----	----	18	----	----	18	[3] 22	----	22	----	----
	9	vf	24	16	4	44	2	----	2	4	8	----	----	----	----	----	----	----	8	10	----	18	[3] 30	----	30	----	----
	11	f–m	28	13	7	48	7	----	----	14	21	----	1	1	----	----	----	----	2	----	----	2	28	----	28	----	----
	12	f–m	26	5	5	36	11	1	2	15	29	----	1	1	----	2	----	2	3	----	----	3	9	----	9	----	20
Eoline member	13	f	26	5	10	41	10	----	----	1	11	----	----	----	1	1	1	3	6	----	----	6	27	12	39	----	----
	14	f	23	14	2	39	4	2	----	1	7	----	1	1	1	1	----	2	15	5	----	20	25	5	30	----	1
	16	f	31	8	5	43	19	----	----	6	25	1	----	1	----	----	2	2	----	----	1	1	28	----	28	----	----
	17	vf–f	24	24	4	52	10	----	----	2	12	----	2	2	----	----	----	----	18	2	2	22	4	----	4	[7] 4	4
	22	vf	10	16	----	26	2	----	----	----	2	----	4	4	----	----	----	----	8	2	----	10	58	----	58	----	----
	24	f–m	22	5	5	32	2	1	1	7	11	----	2	2	1	----	1	2	5	3	6	14	39	----	39	----	----
	25	f	26	7	3	36	8	3	----	1	12	1	----	1	1	1	4	6	3	----	15	18	----	14	14	----	13
	27	f–m	29	9	1	39	7	----	1	12	20	3	----	3	1	1	1	3	----	----	3	3	32	----	32	----	----
	28	m	29	10	4	43	14	1	1	10	26	6	----	6	----	1	----	1	1	----	----	1	10	----	10	[11] 1	12

1 vf, very fine; f, fine; m, medium.
2 Detrital garnet.
3 Brown-stained clay paste.
4 Spherulites of siderite.
5 1 percent sandstone grains, 1 percent fragments of spherulitic chalcedony, 2 percent rims of chalcedony on grains of sand framework.
6 Thin rims of chalcedony on grains.
7 Claystone.
8 Thin section sample 1 from Webb core consists of a pebble of metaquartzite from the Gordo formation.
9 Thin section sample 15 from Webb core consists of silicified lignite(?) with spherules of chalcedony filling pores of cells.
10 Detrital pale-green tourmaline.
11 Chert cement.

TABLE 10—*Percentage of rock-forming materials in thin sections of silt from the Coker and Eutaw formations*

Formation	Sample	Grain size [1]	Rock and mineral fragments																				Matrix			Other
			Quartz varieties									Rock fragments other than quartz varieties			Mineral grains											
			Individual grains				Composite grains (Rock fragments)								Feldspar				Other							
			Unstrained	Moderately strained	Strongly strained	Total	Subparallel orientation, straight borders	Semiparallel orientation, smooth borders	Random orientation, smooth borders	Random orientation, crenulated borders	Total	Chert	Schist, undifferentiated	Total	Orthoclase	Microcline	Plagioclase	Total	Muscovite	Chlorite	Glauconite	Total	Clay paste	Crystalline carbonate cement	Total	
Crawford core hole																										
Eutaw	9	s	14	10	---	24	4	---	---	---	4	---	2	2	---	---	---	---	22	---	4	26	44	---	44	---
Boykin core hole																										
Coker	2	s	18	4	---	22	4	---	---	---	4	---	---	---	---	---	---	---	24	---	---	24	26	---	26	[2] 24
Webb core hole																										
Coker upper member	10	s	12	6	---	18	---	---	---	2	2	1	---	1	---	---	---	---	30	4	---	34	45	---	45	---
Boykin core hole																										
Coker, Eoline member	4	s	7	15	5	27	1	1	---	---	2	---	---	---	---	---	---	---	19	2	1	22	49	---	49	---
	7	s	9	6	---	15	3	---	---	---	3	---	1	1	1	---	1	2	11	---	---	11	68	---	68	---
	8	s	11	5	1	17	4	1	---	2	7	---	---	---	---	---	---	---	21	---	---	21	55	---	55	---
	9	s	20	28	4	52	---	---	---	---	---	---	---	---	---	---	---	---	22	2	---	24	24	---	24	---
	10	s	13	16	7	36	7	---	---	3	10	---	---	---	---	1	---	1	13	---	---	13	40	---	40	---
	11	s	17	11	2	30	6	1	---	3	10	1	---	1	1	---	---	1	6	---	---	6	52	---	52	---
	12	s	19	9	3	31	9	---	---	3	12	---	2	2	1	---	1	2	11	1	---	12	41	---	41	---
Webb core hole																										
Coker, Eoline member	18	s	16	---	2	18	8	---	---	2	10	2	---	2	---	---	---	---	14	---	14	28	42	---	42	---
	19	s	6	6	4	16	---	---	---	---	---	---	---	---	---	---	---	---	30	---	4	34	50	---	50	---
	26	s	9	4	3	16	---	---	---	---	---	---	---	---	---	---	---	---	32	---	2	34	50	---	50	---

[1] s, silt.
[2] Small patches of argillaceous finely crystalline carbonate.

TABLE 11.—*Percentage distribution of constituents of marly sediments at base of Mooreville chalk in samples from Crawford core hole.*

Sample	Depth (feet)	Constituents								
		Argillaceous calcilutite	Crystalline carbonate	Carbonate-filled Foraminifera	Broken shell fragments	Glauconite	Unstrained quartz	Moderately strained quartz	Composite quartz grains	Total
1	6.0	87	--------	12	1	--------	--------	--------	--------	100
2	14.5	85	--------	6	--------	8	--------	1	--------	100
3	21.0	20	19	4	--------	49	6	--------	2	100
4	23.5	47	8	6	--------	28	5	2	4	100

of glauconite are present in outcropping sands of this member. The paucity of glauconite is to be expected, however, as the upper member of the Coker formation is primarily a sequence of red and brown clayey beds.

Table 10, on silt, is not directly comparable with tables 7 to 9 owing to the difference in grain size between sand and silt; the smaller amount of rock fragements in the silt and the larger amount of clay paste and flakes of muscovite and chlorite illustrate this point.

Table 12 shows that the chert-cemented sandstone of the Vick formation, in contrast with the sand and carbonate-cemented sandstone, contains relatively large amounts of the composite quartz grains that are interpreted to be largely of metamorphic origin. Also, the sand and sandstone of the Eoline member of the Coker formation and of the less well sampled Eutaw and McShan formations contain significant amounts of glauconite, and on this basis they can be distinguished from the sand and sandstone of the Vick formation and the upper unit of the Coker. Also, the sand and sandstone of the Eutaw and McShan formations contain significantly larger amounts of glauconite than does the Eoline member.

No quantitative studies were made on the pebbles and granules of the Vick formation, but from available samples it seems that these coarse particles consist largely of chert and of fragments of quartz that are thought to be derived from metaquartzite.

CLAY MINERALS

An attempt was made to differentiate between the clay-bearing sand and silt and the thin clay beds in the pre-Selma formations by means of type and relative abundance of clay minerals. A. J. Gude 3d, of the U.S. Geological Survey, determined the clay minerals by X-ray methods using unfractionated samples. Table 13 shows the results of the clay-mineral analyses, which also include data on quartz and hematite. The samples from the Crawford and Boykin core holes

TABLE 12.—*Average percentages of rock and mineral fragments in thin sections of carbonate-cemented sandstone, chert-cemented sandstone, sand, and silt (matrix and voids excluded)*

Formation	Number of samples	Rock and mineral fragments																					Other
		Quartz varieties									Rock fragments other than quartz varieties				Mineral grains								
		Individual grains				Composite grains (Rock fragments)									Feldspar				Other				
		Unstrained	Moderately strained	Strongly strained	Total	Sub-parallel orientation, straight borders	Semi-parallel orientation, moderately smooth borders	Random orientation, smooth borders	Random orientation, crenulated borders	Total	Chert	Schist, undifferentiated	Phosphatic material	Total	Orthoclase	Microcline	Plagioclase	Total	Muscovite	Chlorite	Glauconite	Total	
Carbonate-cemented sandstone																							
Mooreville chalk	[1] 1	59	3	---	62	21	---	---	---	21	---	---	---	---	---	3	---	3	---	---	---	---	[2] 14
Eutaw	2	49	8	5	62	13	1	---	9	23	2	2	1	5	---	---	---	---	1	---	9	10	---
Coker, Eoline member	3	53	4	1	58	13	1	---	11	25	2	---	---	2	2	3	2	7	---	---	5	5	[3] 3
Chert-cemented sandstone																							
Vick	21	22	6	5	33	24	5	1	26	56	1	1	---	2	---	1	1	2	7	---	---	7	---
Sand																							
Eutaw	2	29	12	5	46	11	2	---	7	20	1	2	---	3	---	3	2	5	4	---	21	25	[4] 1
McShan	1	35	8	3	46	8	---	3	4	15	---	---	---	---	---	3	---	3	13	6	17	36	---
Coker, upper member	12	36	20	9	65	10	1	1	7	19	2	1	---	3	---	1	---	1	9	2	---	11	[5] 1
Eoline member	13	34	17	6	57	11	1	---	10	22	2	2	---	4	2	1	1	4	8	1	4	13	---
Silt																							
Eutaw	1	25	18	---	43	7	---	---	---	7	---	2	---	2	---	---	---	---	22	---	4	26	---
Coker, upper member	2	29	9	---	38	4	---	---	1	5	1	---	---	1	---	---	---	---	53	3	---	56	---
Eoline member	10	24	18	6	48	7	1	---	2	10	1	1	---	2	1	---	---	1	35	1	3	39	---

[1] See table 11 for description of other samples.
[2] Includes shell fragments and detrital garnet.
[3] Shell fragments.
[4] Detrital garnet.
[5] Detrital sandstone and chalcedony.

were glycolated to differentiate between montmorillonite and chlorite. The samples from the Webb hole were not glycolated, and the clay minerals in these samples are reported only in an estimated order of relative abundance whereas those from the Crawford and Boykin holes could be grouped as occurring in major, minor, and trace amounts.

In table 13 samples labelled "a" or "b" are from conglomerates or breccias; samples labelled "a" are from fragments or pebbles of clayey material, those labelled "b" are from the similar clayey matrix surrounding the fragments. These two types of samples were taken to determine whether the clayey fragments were derived from pre-existing sediments or were reworked from nearby areas. As no appreciable differences in the distribution of clay minerals could be found, the fragments are presumed to have been reworked from nearby accumulations of clayey material.

Table 13 shows that kaolinite is most abundant in the upper and lower parts of the Gordo formation (the only parts of that formation available for study); in some layers of the Coker formation, especially in the upper member; and in the Vick formation. Montmorillonite is the dominant clay mineral in the Eutaw and McShan formations and in the Eoline member of the Coker formation, especially in the upper part. Illite or mica and chlorite occur in small amounts, having sporadic distribution in all three cores. Trace amounts of halloysite are present in the Eutaw and McShan formation and in the upper part of the Gordo formation.

CONDITIONS OF ACCUMULATION

Vick formation.—The sediments of the Vick formation were probably deposited by streams over a surface of low relief on rocks of pre-Cretaceous age. The basal pebbly sands may represent reworked lag gravel from this surface of low relief or they may have been derived from areas of higher land. The chert-cemented sandstone beds may represent winnowed stream-deposited material as suggested by their repeated graded bedding and their excellent sorting. Their porosity may also account for the entrance and deposition of the chert cement. It is likely that the chert cement was introduced from without, because almost none of the grains in these beds show signs of compression against adjacent areas, so pressure solution from the nearby grains has probably not been the source of the silica for the chert cement. The source of this silica may have been an area having highly weathered well-drained rocks with a surface of low relief; the dominance of kaolinitic clay in the Vick tends to support this hypothesis. The red beds associated with the Vick formation are probably reworked kaolinitic soils that retained adsorbed iron ions on the clay particles.

TABLE 13.—*Clay mineral varieties, quartz, and hematite, and their relative abundance in the Vick, Coker, Gordo, McShan, and Eutaw formations*

Series	Group	Formation	Member	Sample No.	Depth of Sample (feet)	Quartz	Kaolinite	Illite	Montmorillonite	Chlorite	Halloysite	Hematite	Relative amount of iron
Crawford core hole													
[I, major; II, minor; III, trace]													
Upper Cretaceous		Eutaw		1	121	II	III	III	I	...	...	...	Low.
				2	130	II	...	III	I	...	...	...	Moderate.
				3	164	II	III	III	I	III	III	...	Do.
		McShan		4	190	I	III	III	I	...	...	...	Do.
				5	283	[1] I	III	II	I	III	III	...	Do.
	Tuscaloosa	Gordo		6	400	I	I	II	II	...	III	II	Moderately high.
				7	407	I	III	II	II	III	III	[2] II	Do.
				8	415	I	II	III	III	...	III	[2] I	High.
Boykin core hole													
Upper Cretaceous	Tuscaloosa	Gordo		1	13	I	I	II	...	III	...	...	Low.
		Coker	Upper member	2	41	I	I	II	...	...	...	...	Do.
				3	44	I	I	III	III	...	...	II	High.
				4a	61	I	II	II	III	III	...	I	Do.
				4b	61	I	II	II	III	...	...	I	Very high.
				5a	83	I	II	III	III	III	...	...	Do.
				5b	83	I	II	III	III	III	...	...	Moderate.
				6	170	I	III	III	III	...	...	...	Low.
				7	195	I	III	III	III	III	...	...	Moderate.
				8	202	I	II	III	...	III	...	...	Do.
				9	206	I	II	III	III	III	...	...	Do.
			Eoline	10	227	II	III	III	I	...	...	...	Moderately high.
				11	248	I	III	II	III	I	...	...	Do.
				12	319	II	II	III	I	...	...	...	Do.
				13	349	I	III	III	II	...	...	...	Moderate.
				14	442	I	I	II	III	...	...	...	Do.
				15	467	II	III	III	II	III	...	II	High.

[1] Plus feldspar.
[2] Plus lepidocrocite.

Series	Group	Formation	Member	Sample No.	Depth of sample (feet)	Mineral varieties listed in estimated order of relative abundance
Webb core hole						
Upper Cretaceous	Tuscaloosa	Coker	Upper	1	43	Hematite, quartz, kaolinite, montmorillonite.
				2	45	Quartz, kaolinite, mixed montmorillonite-illite.
				3a	50	Hematite, quartz, kaolinite, montmorillonite.
				3b	50	Quartz, kaolinite, hematite, montmorillonite, halloysite(?).
				4a	65	Quartz, hematite, kaolinite, montmorillonite.
				4b	65	Quartz, kaolinite, mixed montmorillonite-illite.
				5	86	Quartz, hematite, kaolinite, mixed montmorillonite-illite.
				6	90	Kaolinite, quartz, montmorillonite.
				7a	94	Hematite, quartz, kaolinite, montmorillonite.
				7b	94	Siderite, quartz, kaolinite.
				8	107	Quartz, kaolinite, montmorillonite.
				9	113	Quartz, hematite, kaolinite, montmorillonite.
				10	138	Quartz, kaolinite, illite, montmorillonite.
				11	187	Quartz, montmorillonite, kaolinite, illite.
				12	189	Quartz, kaolinite, montmorillonite, illite.
				13	208	Quartz, kaolinite, montmorillonite.
				14	213	Quartz, montmorillonite, kaolinite.
			Eoline	15	221	Montmorillonite, quartz, kaolinite, illite.
				16	226	Montmorillonite, kaolinite, quartz, illite (may be mica).
				17	242	Quartz, montmorillonite, kaolinite, illite (may be mica).
				18	262	Quartz, montmorillonite, mica, kaolinite.
				19a	297	Quartz, montmorillonite, mica, kaolinite, feldspar.
				19b	297	Do.
				20	367	Quartz, montmorillonite, kaolinite, mica, feldspar.
				21	421	Quartz, montmorillonite, kaolinite, mica.
				22	444	Quartz, montmorillonite, kaolinite, mica, feldspar.
Lower Cretaceous		Vick		23	564	Quartz, mica, kaolinite, montmorillonite, feldspar, high Fe.
				24	582	Do.
				25	600	Quartz, mica, kaolinite, montmorillonite, calcite, feldspar, moderate Fe.
				26a	604	Quartz, kaolinite, mica, montmorillonite, feldspar.
				26b	604	Quartz, kaolinite, montmorillonite, mica, feldspar.
				27	616	Quartz, mica, kaolinite, montmorillonite, feldspar, high Fe.

679-264 O—64——5

Coker formation, Eoline member.—The glauconite grains, the thin lignite beds, the thin carbonate-cemented sandstone beds, and the foraminiferal and molluscan remains at certain levels in the Eoline member of the Coker formation all point to shallow-marine to marginal-marine conditions of accumulation. Esther Applin (chapter *D* in this bulletin; Monroe 1955, p. 15) interprets the Foraminifera of the family Saccamminidae, found in these sediments, as indicating deposition in very near shore, only slightly brackish water. The thin carbonate-cemented sandstone beds having shell fragments, probably of mollusks, suggest very brief and very shallow incursions of moderately agitated marine waters. In contrast, the relatively large amounts of silt and clay and the considerable range in the degree of sorting of these sediments suggest accumulation in shallow marine embayments in sheltered coastal areas. The montmorillonitic clay in the Eoline member, especially abundant at the top of the unit, may represent volcanic material, but according to C. S. Ross and Charles Milton (written communication, Milton to W. H. Monroe, Sept. 13, 1955) of the U.S. Geological Survey, both of whom examined thin sections of these predonimatly montmorillonitic clays from the top of the Eoline member, there are no shard structures of other clear evidences of volcanic origin. They feel that these montmorillonitic clays may possibly be water transported, possibly from montmorillonitic soils.

Coker formation, upper member.—The dominantly red and brown sediments in the upper member of the Coker formation may represent material derived largely from weathered soils in a source area starting to undergo uplift. These sediments range widely in their degree of sorting, and they are especially poorly sorted in the lower part of the member, suggesting that they represent rapidly deposited, nonreduced material that overwhelmed the shallow marine lagoons and local coal swamps that existed during accumulation of the Eoline member. The abundance of iron-stained kaolinitic clay in the upper member of the Coker formation (table 13) supports the concept ot soil material swept in rapidly from a nearby uplifted surface of relatively low relief. Additional evidence for this interpretation is the gravelly sand that is abundant in the overlying Gordo formation on the outcrop (table 1) and in the subsurface (pl. 1). The coarse clastics in the Gordo may be interpreted as evidence of further uplift of the source area and of the exposure and breakup of bedrock after the soils were largely swept away during the initial uplift.

McShan and Eutaw formations.—Both the McShan and Eutaw formations are of marine orgin, as they contain marine fossils and considerable amounts of glauconite. The sand in the Eutaw formation is better sorted than that in the McShan formation, and this may indicate a tapering off of uplift in the source area after deposition of the Gordo. The moderate amount of randomly distributed silt and clay and the somewhat coarser sand in the McShan and Eutaw formations, as compared with the sand of the Eoline member of the Coker formation, suggest that the sediments in the McShan and Eutaw accumulated in relatively shallow marine water that fluctuated from quiet to well agitated. The thin carbonate-cemented sandstone beds also suggest variability of conditions of accumulation.

Mooreville chalk.—The basal part of the Mooreville chalk is a transitional unit, from the sandy sediments of the Eutaw formation to the argillaceous calcilutite of the Mooreville which has calcite-filled Foraminifera largely of pelagic types. These samples of the Mooreville suggest that the chalk formed in shallow water or was deposited during a landward encroachment of the sea with consequent deepening of the waters in the area from which the core samples were taken.

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