GEOLOGY, STRATIGRAPHIC RELATIONSHIPS, AND CHEMICAL COMPOSITION OF PHOSPHATIC DRILL CORES (TACTS BOREHOLES) FROM THE CONTINENTAL SHELF OFF GEORGIA

Edited By
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Department of Natural Resources
Environmental Protection Division
Georgia Geologic Survey

Project Report No. 17

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Prepared in cooperation with
U.S. Minerals Management Service and the
U.S. Geological Survey
U.S. Department of the Interior
under MMS Agreement No. 14-12-0001-30496

This report is preliminary and has not been reviewed for conformity with
U.S. Geological Survey or Georgia Geologic Survey editorial standards and stratigraphic nomenclature.

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Atlanta, Georgia
1992

Project Report No. 17

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Cover illustration. Illustration of enrichment of phosphorite at the Middle Miocene-age unconformity (phosphorite pellet concentrations (%), Borehole B., superimposed on a seismic profile). Depths are below sea floor. Small numbers refer to specific depths.

INTRODUCTION

The Georgia shelf lies east of areas of the Georgia mainland and State territorial waters that contain phosphorite in near-commercial concentrations. It lies north and south of phosphatic Tertiary strata as indicated by shallow drill cores (Joint Oceanographic Institutions' Deep Earth Sampling Program - JOIDES) (Atlantic Margin Coring Project - AMCOR)(Hathaway and others, 1970; 1979). However, except for the offshore Savannah Light boring and AMCOR hole 6002 (which has a relatively sparse sample coverage), little is known about sediments under the shelf.

The availablity of new core data to about 100 m water depth from eight sites on the middle Georgia shelf adds greatly to our knowledge of phosphorite distributions, general stratigraphy and ability to calibrate the existing offshore seismic network. These sites are the TACTS boreholes, drilled for the U.S. Navy by the McClelland Co. of Houston, Texas in 1984. The present report provides data on three coreholes. We offer detailed data of original samples and their available weights, locations, lithology and petrography, including volumetric estimates of phosphorite pellet content, chemical analyses, biostratigraphic age dating of the core holes, pellet genesis, and a synthesis of regional geology of Georgia and its adjoining offshore area, including the paleogeography of the mid-Tertiary in the area. The work is a contribution to the offshore Georgia Hard Minerals Task force and its attempt to evaluate the mineral potential and environmental factors in the EEZ area off Georgia.

Emergence of phosphorite potential off Georgia

The first evidence that phosphorite deposits off the Savannah, Georgia, might hold commercial potential and that these might be recovered competitively with existing land deposits in Florida and North Carolina were the Kerr-McGree lease requests to the State of Georgia in the late 1960's and the Zellars-Williams economic analysis of 1979. The possible viability of offshore phosphorite recovery ran counter to widely held assumptions about offshore mining. These new assessments were partly based on demographic changes and increased environmental/regulatory pressures and costs for onshore mineral recovery operations. A recent economic evaluation (Zellars-Williams, 1988) offers an innovative technological scenario to permit offshore phosphorite mining by deep dredging (to as much as 50 m) coupled with an artificial-island preprocessing plant. Borehole mining, a development by the U.S. Bureau of Mines, later tested by private industry in northern Florida, was not considered in the Zellars Williams report.

Significance of the North Carolina and Georgia offshore studies

Vibracore and seismic studies of S.R. Riggs and his coworkers off North Carolina drew attention to potential phosphorite deposits in the subsurface of Onslow Bay, North Carolina (Riggs, 1984; Marvasti and Riggs, 1987; Riggs and Manheim, 1988 and Riggs and others, 1985).

The stratigraphic continuity of the North Carolina-Florida phosphatic middle Tertiary in the Exclusive Econimic Zone off Georgia has been suggested by various lines of evidences, including shallow seismic studies off Georgia by

Kellam and Henry (1986), Popenoe (1986; 1991) and Kellam et al, 1990. However, interpretation of the seismic data has been handicapped by a lack of borehole information on paleontologic age, lithology, and phosphate distribution. Although the new Zellars-Williams report (1988) makes use of the USGS-seismic reflection coverage of the area for compiling isopach maps of the Miocene and post-Miocene sediments (Popenoe and Spalding, 1988), no additional sediment verification beyond the earlier data from the Savannah Light well (Zellars-Williams, 1979) was utilized for stratigraphic maps that encompass the entire EEZ off Georgia. Until recently only one other usable stratigraphic borehole, AMCOR 6002, was available until recently off the Georgia EEZ for ground verification purposes (Hathaway and others, 1979; Manheim and others, 1980, Poppe, 1981). Other borings yielded only cuttings and lacked geophysical logs within the Neogene strata (Fig. 7-1).

Development of borehole mining systems applicable to deeper offshore phosphorite

An experimental borehole mining system initiated by the U.S. Bureau of mines and tested by AGRICO Co. (Scott, 1982; Savanick, 1985) demonstrated the technical feasibility of recovering deeper phosphorites to more than 100 m below sea floor where sufficient formation strength in upper layers permitted. This technique potentially opens up more than 10,000 km^2 of deeper strata to mineral recovery.

The possibility of control of turbidity by return of fines to the subsurface and minimal disturbance of the shelf surface is an additional, environmentally favorable attribute of the borehole mining technique, but its economic performance has not yet been tested.

The TACTS boreholes

In 1984, the U.S. Navy contracted for eight boreholes to be drilled for foundation evaluation purposes in the offshore Georgia area by the McClelland Co. of Houston, Texas. Cores from these Tactical Air Command Test Site (TACTS) borings were made available to the Branch of Atlantic Marine Geology of the U.S. Geological Survey and are stored at the Woods Hole Oceanographic Institution (WHOI) core and rock repository in Woods Hole, Mass.

Although the TACTS drill cores do not represent continuous coverage of penetrated strata (about 100 m), they are sited in key areas of the inner Georgia EEZ. After proposals and discussions in 1987, a cooperative study of the TACTS borings by the U.S. Geological Survey, Georgia Geological Survey, and Georgia State University was initiated in early 1988, sponsored by the U.S. Minerals Management Service, the U.S. Geological Survey, and the Bureau of Mines.

This report provides information on lithology, stratigraphy, phosphate distribution and supporting chemical information on eight Tacts boreholes, as well as interpretations of phosphorite genesis, and the regional geologic and resource significance of the new data. It supersedes an earlier progress report (Manheim and others, 1989). Extensive seismic stratigraphic data and major element and trace element data are provided in companion reports: Popenoe, 1991, and Herring et al, 1991).

Acknowledgements

We thank M. Cruickshank, formerly of USGS, Reston, VA., and S.J. Williams, USGS, for assistance in acquiring the TACTS cores; Gary Skipp, USGS, Denver, for assistance in core sampling; D. Blackwood and D. Lubinski of the USGS, Woods Hole for help in preparing special illustrations; C.W. Poag of USGS, Woods Hole, for foraminiferal identifications; J. Commeau for earlier chemical analyses, J. Taggart and colleagues from the Geochemical Branch, Denver CO for carefully performed chemical analyses, J. Broda and C.E. Franks of the Woods Hole Oceanographic Institution for assistance in accessing cores, and McClelland Co. of Houston, Texas, for background information and help regarding the TACTS cores. The financial support of the U.S. Minerals Management Service is gratefully acknowledged.

II LOCATION AND CORE BACKGROUND DATA

By F. T. Manheim and J. R. Herring

The locations of all known drill cores in the EEZ section are depicted in Figure II-1 and Table II-1. However, only the TACTS, AMCOR, and JOIDES cores offer useful material for present purposes, since the other wells drilled through the key Neogene strata. Other boreholes recovered only cuttings that are not useful in evaluating detailed stratigraphy or economic potential. Geophysical logging generally encompassed only post-Neogene horizons.

The TACTS core materials exist in three forms: pint Mason jars of artificially consolidated materials left from physical properties tests such as triaxial compressive strength; intact core sections of a few inches to 1' in plastic tubes of 2.5" (6.5 cm) inner diameter; and bags of loose material, generally from near-surface sections. The cores are clearly the best preserved and best depth-defined. They have been used whenever a choice was available. They also experienced the least drying.

We created new designations for the TACTS boreholes to eliminate confusion between the Navy and McClelland numbering systems and to permit straightforward computer coding (Table II-2). Tables II-3 to II-10 list the total available samples in the WHOI core repositories along with presampling weights.

We can estimate roughly the proportion of the hole volume for which core was available by summing sample weights against the equivalent weight of total volume of the borehole core diameter (Table II-11). The mean density of 6 samples used to estimate sediment density is 1.73. However, though they appeared fresh, the length and conditions of storage suggested that some evaporation has taken place. Therefore we computed a mean nonphosphatic bulk density of 1.667 from water content data in J-2 and J-1 (wells on the Florida shelf near the Georgia border). The formula used was:

$$D_{sed} = 1/[((1-W)G_{sed}) + W]$$

where W is fractional water content (g/g) and Gsed is mineral grain density of nonphosphatic sediment, assumed to be 2.60 g/cm^3. This value corresponds to a mean water content of 0.35 (35% wet weight) for the strata, which value was used later to convert between volume and weight units. Units are not salt-corrected, which could be done by assuming occluded water had a salt contents of about 3.5%.

Table II-1. Location and other information for boreholes in Georgia and adjoining areas. Abbreviations are JOIDES: Joint Oceanographic Insitutions Deep Earth Sampling Program (NSF); COST: Continental Offshore Stratigraphic Test (Scholle, 1979); AMCOR: Atlantic Continental Margin Coring Project 1976 (Hathaway and others, 1979); SL: Savannah Light boring, U.S. Coast Guard.

DATE	SITE NO.	LATITUDE (NORTH)	LONGITUDE (WEST)	WATER DEPTH (M)	WATER DEPTH (FT)	PENETRATION DEPTH (M)	PENETRATION DEPTH (FT)	ORIGINATOR
1962-63	SL	31.948	80.666	16	52	47	154	U.S.C.G.
1965	J-1	30.550	81.000	25	82	277	910	JOIDES
1965	J-2	30.350	80.333	42	138	173	569	JOIDES
1965	J-5	30.383	80.133	190	623	245	804	JOIDES
1965	J-6	30.083	79.250	805	2,640	120	393	JOIDES
1976	6002	31.149	80.518	32	106	304	1,000	AMCOR
1976	6004	32.077	79.107	174	570	308	1,010	AMCOR
1979	T-1 +	30.790	80.473	35	115	2,292	7,518	TENNECO
1979	T-2 +	30.602	80.534	30	98	2,211	7,252	TENNECO
1979	GT-1+	31.080	80.442	35	115	2,070	6,790	GETTY
1979	TR-1+	30.999	80.251	40	131	3,475	11,398	TRANSCO
1979	E-1 +	30.577	80.509	32	105	2,249	7,377	EXXON
1979-80	E-2 +	30.444	80.260	139	455	3,850	12,628	EXXON
1979	GE-1	30.620	80.310	42	136	3,970	13,022	COST
1984	A	31.846	80.274	25	81†	98	321	U.S. NAVY•
1984	B	31.633	79.925	45	146†	91	300	U.S. NAVY•
1984	C	31.533	80.233	35	115†	102	336	U.S. NAVY•
1984	D	31.395	80.566	26	86†	98	323	U.S. NAVY•
1984	E	31.216	80.116	43	147†	92	302	U.S. NAVY•
1984	F	31.049	80.449	32	105†	100	329	U.S. NAVY•
1984	G	30.941	80.749	25	83†	97	319	U.S. NAVY•
1984	H	30.799	80.316	41	135†	97	319	U.S. NAVY•

† The depth of the TACTS core samples was given for mean low water, other the samples presumed mean sea level.
• By McClelland Company
+ No or marginal data known to be useful for phosphate evaluation at this time.

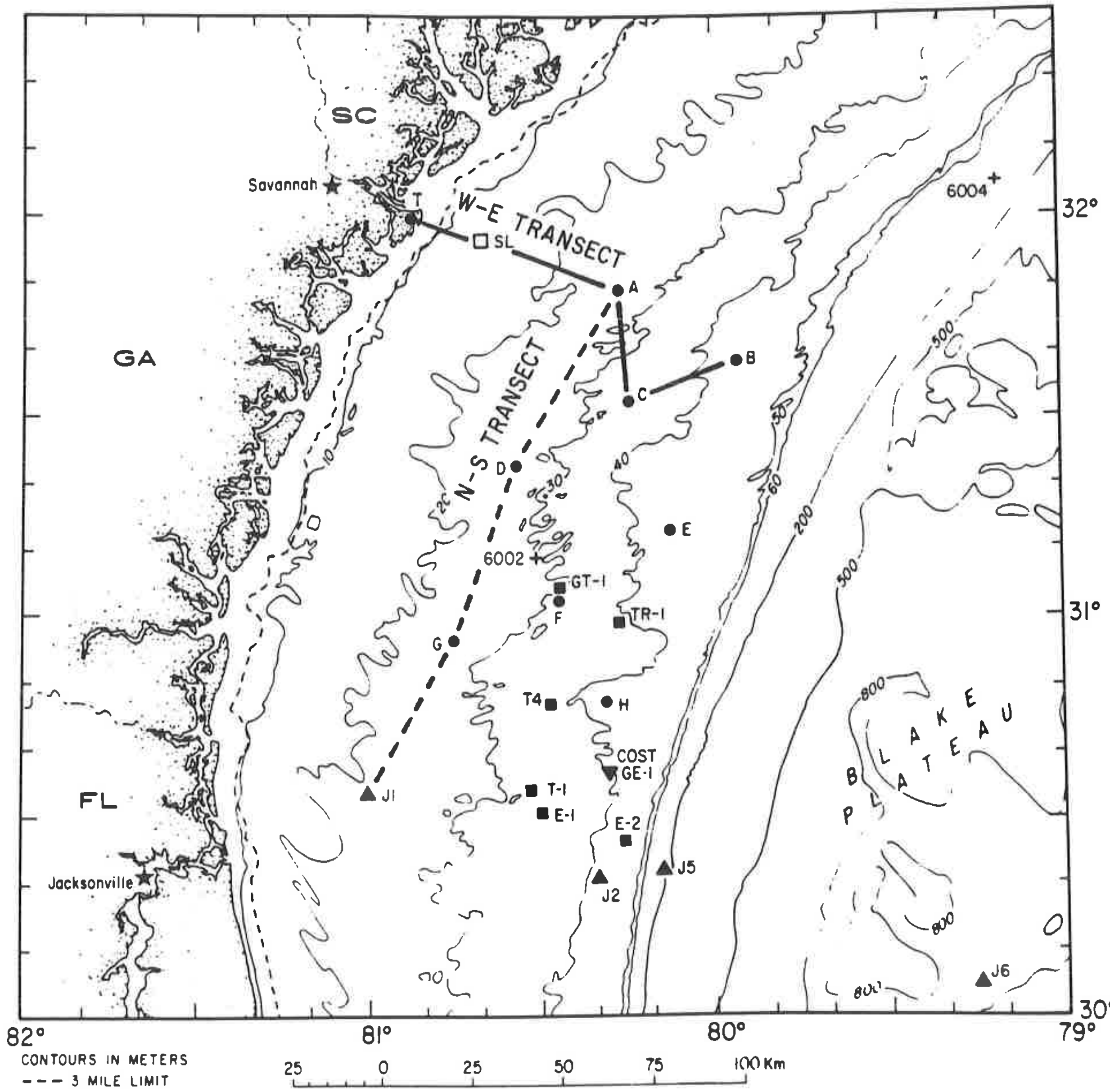

Figure II-1. Location map of offshore samples. Keys to symbols are in Table II-1. Transect lines refer to figures in Ch. III.

Table II-2. Cross reference, equivalents for TACTS core designations (see text and Figure II-11).

USGS TACTS designation	McClelland TACTS designation	U.S. Navy TACTS designation
A	B-1	R-7
B	B-2	R-8
C	B-3	M2R6
D	B-5	R-2
E	B-4	R-3
F	B-6	M1R1
G	B-8	R-5
H	B-7	R-4

Table II-3. Total samples available in USGS core holdings for TACTS Borehole A cores prior to sampling. T refers to cores stored in tubes, B to bags all others jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
A1.1	3.5	B1	S1	.10
A1.9	6.2	B1	S2	.00
A2.2	7.2	B1	S4	.00
A2.9	9.5	B1	S3	.15
A3.4	11.0	B1	S5	.36
A4.6	15.0	B1	S6	.22
A5.8	19.0	B1C	S1	3.20
A6.6	21.5	B1	S8	.15
A7.2	23.5	B1	S9	.18
A8.4	27.8	B1	S10	.00
A8.5	28.0	B1C	S2	3.49
A9.3	30.5	B1	S11	.16
A10.5	34.5	B1	S12	.20
A16.1	53.0	B1C	S3	2.78
A17.2	56.5	B1	S15	.15
A17.4	57.0	B1	S16	.16
A17.7	58.0	B1	S18	.10
A20.6	67.5	B1	S17	.22
A24.4	80.0	B1	S19	.25
A25.9	85.0	B1	S20	.16
A26.0	85.5	B1	S21	.10
A26.1	85.5	B1	S21	.46
A26.2	86.0	B1	S22	.30
A27.4	90.0	B1	S23	.64
A27.6	90.5	B1	S24	.45
A30.2	99.0	B1	S25	.32
A30.3	99.5	B1	S26	.20
A33.1	108.5	B1	S27	.45
A33.2	109.0	B1	S28	.30
A33.4	109.5	B1	S29	.46
A36.6	120.0	B1	S31	.71
A36.7	120.5	B1	S32	.22
A39.6	130.0	B1	S33	.15
A39.7	130.5	B1	S34	.10
A39.8	130.5	B1	S34	.48
A39.9	131.0	B1	S35	.41
A42.6	140.0	B1	S36	.45
A42.7	140.0	B1	S38	.25
A42.8	140.5	B1	S37	.90
A45.1	148.0	B1	S39	.10
A45.3	148.5	B1	S40	.15
A48.0	157.5	B1	S41	.23
A48.2	158.0	B1	S43	.23
A48.6	159.5	B1	S42	.71
A51.2	168.0	B1	S45	.08
A51.4	168.5	B1	S46	.35

A51.7	169.5	B1	S44	.87
A54.6	179.0	B1	S47	.30
A54.7	179.5	B1	S48	.47
A54.9	180.0	B1	S49	.25
A57.1	187.3	B1	S50	.00
A58.2	190.8	B1	S51	.35
A60.0	197.0	B1	S52	.10
A60.4	198.0	B1	S54	.22
A61.1	200.5	B1	S53	.96
A62.7	206.0	B1	S55	.70
A62.8	206.0	B1	S55	.15
A62.9	206.5	B1	S56	.23
A65.8	216.0	B1	S57	.43
A66.0	216.5	B1	S58	.30
A66.1	217.0	B1	S59	.20
A68.6	225.0	B1	S60	.44
A72.1	236.5	B1	S62	.98
A72.2	237.0	B1	S63	.42
A81.4	267.0	B1	S66	.97

Table II-4. Total samples available in USGS core holdings for TACTS Borehole B cores prior to sampling. T refers to cores (tubes); B to bags; all others, jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
B0.2	0.5	B-2	S-1	.1
B1.4	4.5	B-2	S-2	.15
B2.4	7.8	B-2	S-3	.1
B2-9	10.0	B-2C	S-1B	.22
B3.0	10.0	B-2C	S-1B	.1
B3.1	10.5	B-2C	S-4	.65
B3.2	10.5	B2C	S-1B	.35
B3.3	10.5	B2	S-1C(a)	~0
B3.3	10.5	B2C	S-1C(b)	1.12
B4.1	13.5	B2	S-5	.1
B5.0	16.5	B2	S-6	.22
B5.4	18.0	B2C	S-2	1.36
B5.5	18.0	B2C	S-2	1.6
B5.9	19.5	B2	S-7	.1
B7.0	23.0	B2	S-8	.09
B7.9	26.0	B2	S-9	.22
B9.1	30.0	B2	S-10	.15
B10.0	33.0	B2	S-11	.65
B11.0	36.0	B2	S-12	.15
B12.2	40.0	B2	S-13	.5
B12.8	42.0	B2	S-14	.48
B14.8	48.5	B2	S-15	.2
B20.9	68.5	B2	S-17	.1
B24.1	79.0	B2	S-18	.46
B24.8	81.5	B2C	S-20	1.14
B30.6	100.5	B2	S-25	.3
B31.1	102.0	B2C	S-26	.38
B34.0	111.5	B2C	S-28	.88
B37.2	122.0	B2C	S-30	.68
B37.3	122.5	B2C	S-31	.05
B37.5	123.0	B2C	S-32	.3
B40.1	131.5	B2C	S-33	.31
B40.2	132.0	B2C	S-34	.9
B40.4	132.5	B2C	S-35	.3
B43.2	142.0	B2C	S-36	.2
B43.3	142.0	B2	S-37	.25
B43.6	143.0	B2C	S-38	.3
B46.2	151.5	B2	S-39	.25
B46.3	152.0	B2C	S-40	.3
B49.2	161.5	B2C	S-41	.2
B49.4	162.0	B2C	S-42	.68
B49.5	162.5	B2C	S-43	.25
B49.6	162.5	B2C	S-43	.1
B52.4	172.0	B2C	S-44	.22
B52.6	172.5	B2C	S-45	.15
B52.7	172.8	B-2C	S-45	.1
B52.8	173.0	B-2C	S-46	.35

B55.6	182.5	B-2C	S-47	.88
B55.8	183.0	B-2C	S-48	.17
B58.5	192.0	B-2C	S-49	.92
B58.7	192.5	B-2	S-50	.25
B58.8	193.0	B-2C	S-51	.46
B61.6	202.0	B-2C	S-52	1.1
B61.8	202.5	B-2C	S-53	.14
B64.6	212.0	B-2C	S-54	.23
B64.8	212.5	B-2C	S-55	1.0
B64.9	213.0	B-2C	S-56	.43
B67.7	222.0	B-2C	S-57	.79
B67.8	222.5	B-2	S-58	.22
B68.0	223.0	B-2C	S-58	.44
B70.4	231.0	B-2C	S-60	.75
B70.6	231.5	B-2	S-61	.43
B70.7	232.0	B-2C	S-62	.3
B73.2	240.0	B-2C	S-63	.21
B73.6	241.5	B-2C	S-64	.89
B73.8	242.0	B-2C	S-65	.43
B76.2	250.0	B-2C	S-66	.7
B76.4	250.5	B-2C	S-67	.98
B76.5	251.0	B-2C	S-68	.3
B79.2	260.0	B-2C	S-66	.16
B79.4	260.5	B-2	S-70	.38
B79.6	261.0	B-2C	S-71	.47
B82.3	270.0	B-2C	S-72	.69
B82.4	270.5	B-2	S-73	.19
B82.6	271.0	B-2C	S-74	.35
B85.0	279.0	B-2C	S-75	.23
B85.2	279.5	B-2C	S-76	.9
B85.6	281.0	B-2C	S-77	.3
B88.1	289.0	B-2C	S-78	.82
B88.2	289.5	B-2	S-79	.38
B88.4	290.0	B-2C	S-80	.23
B91.1	299.0	B-2C	S-81	.2
B91.3	299.5	B-2C	S-82	.97
B91.4	300.0	B-2C	S-83	.46

Table II-5. Total samples available in USGS core holdings for TACTS Borehole C cores prior to sampling. T refers to cores (tubes), B to bags, all others, jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
C0.2	0.5	B-3	S-1	.15
C1.5	1.5-2.1	B-3	P-1,B	.15
C3.2	10.5	B-3	S-3	.1
C4.1	13.5	B-3	S-4	.16
C5.0	16.5	B-3	S-5	.07
C5.3	17.5	B-3	S-8,A	.68
C5.6	18.5	B-3	S-6	.3
C6.6	21.5	B-3	S-7	.2
C7.8	25.5	B-3	S-9	.1
C8.7	28.5	B-3	S-10	.1
C9.3	30.5	B-3	S-11	.4
C10.4	34.0	B-3	S-12	.16
C11.0	36.0	B-3	S-12,B	1.45
C11.3	37.0	B-3	S-13	.16
C12.2	40.0	B-3	S-14	.22
C14.0	46.0	B-3	S-15	.24
C14.8	48.5	B-3	S-15	.20
C17.7	58.0	B-3C	S-17	.87
C17.8	58.5	B-3	S-18	.46
C18.0	59.0	B-3C	S-19	.30
C20.7	68.0	B-3C	S-20	.90
C20.9	68.5	B-3	S-21	.25
C21.0	69.0	B-3C	S-22	.48
C23.8	78.0	B-3C	S-23	.70
C23.9	78.5	B-3	S-24	.36
C24.1	79.0	B-3C	S-25	.38
C26.4	86.5	B-3C	S-26	.94
C26.7	87.5	B-3	S-27	.26
C26.8	88.0	B-3C	S-28	.47
C29.1	95.5	B-3C	S-29	.46
C29.3	96.0	B-3C	S-30	.40
C32.3	106.0	B-3C	S-31	.68
C32.5	106.5	B-3	S-32	.35
C32.6	107.0	B-3C	S-33	.27
C35.1	115.0	B-3C	S-34	.68
C35.2	115.5	B-3C	S-35	.38
C35.4	116.0	B-3C	S-36	.40
C37.2	122.0	B-3C	S-37	.70
C37.3	122.5	B-3	S-38	.30
C37.5	123.0	B-3C	S-39	.44
C40.5	133.0	B-3C	S-40	1.0
C40.7	133.5	B-3C	S-41	.30
C40.8	134.0	B-3C	S-42	.47
C43.9	144.0	B-3	S-43	.40

C44.0	144.5	B-3	S-44	.25
C46.6	153.0	B-3C	S-45	.05
C50.1	164.5	B-3C	S-46	.45
C50.3	165.0	B-3C	S-47	.42
C53.3	175.0	B-3C	S-48	.89
C53.5	175.5	B-3C	S-49	.41
C53.6	176.0	B-3C	S-50	.45
C56.4	185.0	B-3C	S-51	.90
C56.5	185.5	B-3C	S-52	.50
C56.7	186.0	B-3B	S-53	.47
C59.4	195.0	B-3C	S-54	1.0
C59.6	195.5	B-3	S-55	.43
C59.7	196.0	B-3C	S-56	.38
C62.2	204.0	B-3C	S-57	1.0
C62.3	204.5	B-3C	S-58	.50
C65.5	205.0	B-3C	S-59	.44
C65.3	214.0	B-3	S-60	.99
C65.4	214.5	B-3	S-61	.45
C65.5	215.0	B-3C	S-62	.45
C68.0	223.0	B-3C	S-63	1.0
C68.1	223.5	B-3C	S-64	.44
C68.3	224.0	B-3C	S-65	.48
C71.6	235.0	B-3C	S-66	1.09
C71.8	235.5	B-3C	S-67	.63
C71.9	236.0	B-3C	S-68	.40
C73.8	242.0	B-3C	S-69	1.0
C73.9	242.5	B-3	S-70	.45
C74.1	243.0	B-3C	S-71	.46
C76.8	252.0	B-3C	S-72	.99
C77.0	252.5	B-3C	S-73	.45
C77.1	253.0	B-3C	S-74	.50
C78.0	262.0	B-3C	S-75	.90
C80.0	262.5	B-3C	S-76	1.10
C80.2	263.0	B-3	S-77	.10
C82.9	272.0	B-3C	S-78	.98
C83.1	272.5	B-3C	S-79	1.0
C83.2	273.0	B-3C	S-80	.16
C86.9	285.0	B-3C	S-84	.39
C87.0	285.5	B-3	S-81	.21
C87.2	286.0	B-3C	S-82	.40
C89.8	294.5	B-3C	S-83	.46
C96.0	315.0	B-3C	S-85	1.0
C96.2	315.5	B-3	S-86	.41
C96.3	316.0	B-3C	S-87	.44
C102.1	335.0	B-3C	S-88	1.10
C102.3	335.5	B-3	S-89	.43
C102.4	102.4	B-3C	S-90	.48

Table II-6. Total samples available in USGS core holdings for TACTS Borehole D cores prior to sampling. T refers to cores (tubes); B to bags; all others, jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
D0.3	1.0	B-5	S-6	.16
D0.7	2.4	B-5	S-7	.14
D1.5	5.0	B-5	S-8	.45
D2.7	9.0	B-5	S-11	.43
D4.3	14.0	B-5	S-13	.15
D5.2	17.0	B-5	S-14	.26
D6.9	22.5	B-5	S-16	.20
D8.8	29.0	B-5	S-18	.38
D9.4	31.0	B-5	S-17	3.40
D10.7	35.0	B-5	S-20	.45
D10.8	35.5	B-5	S-21	.1
D10.8	35.5	B-5	S-21	.9
D11.6	38.0	B-5	S-22	1.1
D11.7	38.5	B-5	S-23	.2
D14.2	46.5	B-5	S-1	.66
D14.3	47.0	B-5	S-2	.4
D17.8	58.5	B-5	S-3	.35
D18.0	59.0	B-5	S-4	.5
D18.1	59.5	B-5	S-5	.24
D18.4	60.5	B-5	S-24	.2
D21.3	70.0	B-5	S-25	.1
D21.5	70.5	B-5	S-26	1.0
D21.6	71.0	B-5	S-27	.3
D24.4	80.0	B-5	S-28	.23
D24.5	80.5	B-5	S-29	.45
D24.7	81.0	B-5	S-30	.26
D27.4	90.0	B-5	S-31	.7
D27.6	90.5	B-5	S-32	.25
D27.7	91.0	B-5	S-33	.3
D30.5	100.0	B-5	S-34	.14
D33.5	110.0	B-5	S-35	.32
D33.7	110.5	B-5	S-36	.89
D33.8	111.0	B-5	S-37	.23
D36.9	121.0	B-5	S-38	.12
D37.0	121.5	B-5	S-39	.45
D37.1	121.5	B-5	S-39	.07
D37.5	123.0	B-5	S-40	.21
D39.8	130.5	B-5	S-41	.25
D39.9	131.0	B-5	S-42	.16
D43.9	144.0	B-5	S-43	.16
D44.0	144.5	B-5	S-44	1.0
D44.2	145.0	B-5	S-45	.3
D46.9	154.0	B-5	S-46	1.1
D47.1	154.5	B-5	S-47	.44
D48.9	160.5	B-5	S-48A	.5
D49.1	161.0	B-5	S-49	.15

D52.7	173.0	B-5	S-50	.15
D52.9	173.5	B-5	S-51A	.2
D52.9	173.5	B-5	S-51B	.11
D53.0	174.0	B-5	S-52	.23
D55.6	182.5	B-5	S-53	.7
D55.8	183.0	B-5	S-54	.42
D55.9	183.5	B-5	S-55	.25
D58.8	193.0	B-5	S-56	1.0
D59.0	193.5	B-5	S-57	.45
D61.6	202.0	B-5	S-73	.21
D61.7	202.5	B-5	S-59	.14
D63.9	209.5	B-5	S-60	.45
D64.3	211.0	B-5	S-61	.21
D66.6	218.5	B-5	S-62	.68
D70.0	229.5	B-5	S-63	.38
D70.3	230.5	B-5	S-64	.1
D73.3	240.5	B-5	S-65	.05
D76.4	250.5	B-5	S-66	.25
D79.4	260.5	B-5	S-68	.41
D79.6	261.0	B-5	S-69	.2
D82.8	271.5	B-5	S-70	.2
D82.9	272.0	B-5	S-71	.21
D85.8	281.5	B-5	S-72	.22
D91.0	298.5	B-5	S-74	.18
D91.1	299.0	B-5	S-75	.3
D98.3	322.5	B-5	S-76	.2
D98.5	323.0	B-5	S-77	.22

Table II-7. Total samples available in USGS core holdings for TACTS Borehole E cores prior to sampling. T refers to cores (tubes); B to bags; all others, jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
E4.6	15.0	B-4C	S-1	1.6
E5.5	18.0	B-4	S-7	.45
E10.7	35.0	B-4	S-14	.46
E11.6	38.0	B-4	S-15	.36
E12.5	41.0	B-4	S-16	.21
E14.6	48.0	B-4	S-17	.18
E17.7	58.0	B-4	S-18	.5
E23.5	77.0	B-4	S-20	.39
E26.5	87.0	B-4	S-21	.40
E29.4	96.5	B-4	S-22	.30
E29.6	97.0	B-4	S-23	.5
E32.6	107.0	B-4	S-24	.45
E35.7	117.0	B-4	S-25	.44
E35.8	117.5	B-4	S-26	.23
E36.0	118.0	B-4	S-27	.22
E38.7	127.0	B-4	S-28	.24
E41.8	137.0	B-4	S-29	.42
E44.8	147.0	B-4	S-30	.40
E48.0	157.5	B-4	S-31	.28
E48.2	158.0	B-4	S-32	.44
E51.1	167.5	B-4	S-33	.16
E54.4	178.5	B-4	S-34	.40
E54.6	179.0	B-4	S-35	.28
E57.8	189.5	B-4	S-36	.85
E57.9	190.0	B-4	S-37	.1
E60.7	199.0	B-4	S-38	.23
E60.8	199.5	B-4	S-39	1.0
E61.0	200.0	B-4	S-40	.30
E64.5	211.5	B-4	S-41	.60
E64.6	212.0	B-4	S-42	.15
E67.1	220.0	B-4	S-43	.90
E67.2	220.0	B-4	S-44	.23
E67.4	221.0	B-4	S-45	.22
E70.0	229.5	B-4	S-46	.43
E70.1	230.0	B-4	S-47	.15
E73.0	239.5	B-4	S-48	.25
E73.3	240.5	B-4	S-50	.22
E76.0	249.5	B-4	S-51	.45
E76.2	250.0	B-4	S-52	.23
E76.3	250.3	B-4	S-53	.28
E79.1	259.5	B-4	S-54	.40
E79.2	260.0	B-4	S-55	.39
E82.1	269.5	B-4	S-56	.25
E82.4	270.5	B-4	S-57	.35
E82.6	271.0	B-4	S-58	.35
E85.6	281.0	B-4	S-59	.28

E88.5	290.5	B-4	S-60	.46
E88.7	291.0	B-4	S-61	.20
E91.4	300.0	B-4	S-62	.30
E91.6	300.5	B-4	S-63	.85
E91.8	301.3	B-4	S-64	.22

Table II-8. Total samples available in USGS core holdings for TACTS Borehole F cores prior to sampling. T refers to cores (tubes); B to bags; all others, jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
F0.1	0.3	B-6	S-13A,B	.22
F0.2	0.5	B-6	S-1	.22
F2.9	9.5	B-6	S-3	.11
F3.4	11.0	B-6	S-4	.65
F5.8	19.0	B-6	S-6	1.45
F5.9	19.0	B-6	S-7	.43
F6.7	22.0	B-6	S-8	.31
F7.0	23.0	B-6	S-9	.43
F8.0	26.1	B-6	S-10	~0
F10.1	33.0	B-6	S-12	.43
F12.0	39.5	B-6	S-13B	.39
F12.2	40.0	B-6	S-13C	.15
F18.9	62.0	B-6	S-16(a)	1.0
F18.9	62.0	B-6	S-16(b)	.7
F19.0	62.0	B-6	S-16	1.16
F20.6	67.5	B-6	S-18	1.1
F23.8	78.0	B-6	S-20	.98
F23.9	78.5	B-6	S-21	1.2
F27.0	88.5	B-6	S-24	.5
F30.2	99.0	B-6	S-26	.69
F30.3	99.5	B-6	S-27	.41
F33.4	109.5	B-6	S-30	.35
F36.3	119.0	B-6	S-32	.68
F36.4	119.5	B-6	S-33	.3
F39.3	129.0	B-6	S-35	.68
F39.5	129.5	B-6	S-36	.35
F42.7	140.0	B-6	S-38	.18
F42.8	140.5	B-6	S-39	1.0
F43.0	141.0	B-6	S-40	.39
F45.7	150.0	B-6	S-41	.7
F45.9	150.5	B-6	S-42	.45
F46.0	151.0	B-6	S-43	.35
F48.8	160.0	B-6	S-44	.34
F48.9	160.5	B-6	S-45	1.1
F49.1	161.0	B-6	S-46	.28
F52.0	170.5	B-6	S-48	1.09
F52.1	171.0	B-6	S-49	.29
F55.0	180.5	B-6	S-50	.51
F55.2	181.0	B-6	S-51	.5
F58.1	190.5	B-6	S-52	.49
F58.2	191.0	B-6	S-53	.3
F61.4	201.5	B-6	S-54	.22
F61.6	202.0	B-6	S-55	.7
F61.7	202.5	B-6	S-56	.27

F64.0	210.1	B-6	S-57	.15
F67.1	220.0	B-6	S-58	.13
F67.2	220.5	B-6	S-59	.44
F67.4	221.0	B-6	S-60	.17
F70.1	230.0	B-6	S-61	.22
F70.3	230.5	B-6	S-62	.9
F70.4	231.0	B-6	S-63	.19
F72.8	239.0	B-6	S-64	.9
F73.0	239.5	B-6	S-65	.42
F73.1	240.0	B-6	S-66	.24
F75.9	249.0	B-6	S-67	1.09
F76.0	249.5	B-6	S-68	.23
F76.2	250.0	B-6	S-69	.22
F78.9	259.0	B-6	S-71	.44
F79.1	259.5	B-6	S-70	.90
F79.2	259.5	B-6	S-72	.25
F81.7	268.0	B-6	S-73	.95
F81.8	268.5	B-6	S-74	.46
F82.0	269.0	B-6	S-75	.45
F84.7	278.0	B-6	S-76	1.1
F84.9	278.5	B-6	S-77	.46
F85.0	279.0	B-6	S-78	.44
F87.5	287.0	B-6	S-79	.24
F87.6	287.5	B-6	S-80	.22
F87.8	288.0	B-6	S-81	.29
F93.6	307.0	B-6	S-82	.42
F93.7	307.5	B-6	S-83	.16
F99.8	327.5	B-6	S-84	1.18
F110.0	328.0	B-6	S-85	.46
F100.1	328.5	B-6	S-86	.9
F100.3	329.0	B-6	S-87	.2

Table II-9. Total samples available in USGS core holdings for TACTS Borehole G cores prior to sampling. T refers to cores (tubes); B to bags; all others, jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
G0.3	1.0	B-8	S-1	.21
G0.9	3.0	B-8	S-4	.45
G1.8	6.0	B-8	S-5	.23
G2.7	9.0	B-8	S-6	.45
G4.3	14.0	B-8	S-7	.5
G4.9	16.0	B-8	S-8	.05
G5.0	16.3	B-8	S-9(a)	.9
G5.0	16.3	B-8	S-9(b)	1.1
G5.0	16.3	B-8	S-9(c)	.45
G5.2	17.0	B-8	S-10	.21
G5.6	18.5	B-8	S-11	.15
G5.8	19.0	B-8	S-12	.47
G6.4	21.0	B-8	S-13	.07
G7.6	25.0	B-8	S-14	.65
G8.5	28.0	B-8	S-15	.3
G9.3	30.5	B-8	S-16	.23
G10.7	35.0	B-8	S-18	.14
G11.3	37.0	B-8	S-19	.4
G14.0	46.0	B-8	S-20	.25
G17.1	56.0	B-8	S-21	.48
G19.8	65.0	B-8	S-22	.48
G22.9	75.0	B-8	S-23	.42
G25.9	85.0	B-8	S-24	.22
G29.0	95.0	B-8	S-25	.21
G32.0	105.0	B-8	S-26	.21
G35.1	115.0	B-8	S-27	.1
G35.2	115.0	B-8	S-27	.25
G38.1	125.0	B-8	S-28	.24
G41.0	134.5	B-8	S-29	.45
G41.1	135.0	B-8	S-30	.1
G44.2	145.0	B-8	S-31	.45
G47.5	156.0	B-8	S-32	.39
G50.6	166.0	B-8	S-33	.42
G53.6	176.0	B-8	S-34	.19
G56.7	186.0	B-8	S-35	.2
G60.0	197.0	B-8	S-36	.15
G63.4	208.0	B-8	S-37	.25
G63.6	208.5	B-8	S-38	.5
G63.7	209.0	B-8	S-39	.47
G66.0	216.5	B-8	S-1	.5
G66.1	217.0	B-8	S-2	.21
G66.4	218.0	B-8	S-40	.3
G66.8	219.0	B-8	S-42	.49
G66.9	219.5	B-8	S-41	.43
G67.1	220.0	B-8	S-P1	1.95
G69.5	228.0	B-8	S-43	.98

G69.6	228.5	B-8	S-44	.99
G69.8	229.0	B-8	S-45	.22
G72.7	238.5	B-8	S-46	.1
G72.8	239.0	B-8	S-47	.9
G73.0	239.5	B-8	S-48	.23
G75.9	249.0	B-8	S-49	.8
G76.0	249.5	B-8	S-50	.4
G76.2	250.0	B-8	S-51	.29
G78.8	258.5	B-8	S-52	.14
G78.9	259.0	B-8	S-53	1.07
G79.2	260.0	B-8	S-54	.17
G82.0	269.0	B-8	S-55	.9
G82.1	269.0	B-8	S-55	.15
G82.3	270.0	B-8	S-57	.39
G84.9	278.5	B-8	S-58	1.0
G85.0	279.0	B-8	S-59	.37
G85.1	279.3	B-8	S-60	.44
G87.9	288.5	B-8	S-61	.7
G88.1	289.0	B-8	S-62	.22
G88.2	289.3	B-8	S-63	.23
G91.0	298.5	B-8	S-64	1.0
G91.2	299.3	B-8	S-66	.3
G93.6	307.0	B-8	S-68	.23
G93.7	307.5	B-8	S-67	.47
G94.0	308.5	B-8	S-69	.21
G96.8	317.5	B-8	S-70	.9
G96.9	318.0	B-8	S-71	.38
G97.1	318.5	B-8	S-72	.17

Table II-10. Total samples available in USGS core holdings for TACTS Borehole H cores prior to sampling. T refers to cores (tubes); B to bags; all others, jars.

USGS Sample ID (m)	Depth (ft)	McClelland Boring Design.	McClelland Sample Design.	Weight Sample (Kg)
H1.2	4.0	B-7	S-1	2.5
H1.7	5.5	B-7	S-3	.19
H4.7	15.5	B-7	S-6	.05
H7.5	24.5	B-7	S-9	.45
H11.1	36.5	B-7	S-13	.1
H12.2	40.1	B-7	S-14	~0
H13.6	44.5	B-7	S-15	~0
H14.6	48.0	B-7C	S-2	1.0
H15.8	52.0	B-7	S-16	.52
H18.9	62.0	B-7	S-17	.33
H21.9	72.0	B-7	S-18	.28
H25.6	84.0	B-7	S-19	.36
H28.7	94.0	B-7	S-20	.28
H31.9	104.5	B-7	S-21	.37
H34.4	113.0	B-7	S-22	.11
H37.6	123.5	B-7	S-24	1.1
H37.8	124.0	B-7	S-25	.22
H40.5	133.0	B-7	S-26	.9
H40.7	133.5	B-7	S-27	1.06
H40.8	134.0	B-7	S-28	.42
H43.3	142.0	B-7	S-29	.85
H43.4	142.5	B-7	S-30	.85
H43.6	143.0	B-7	S-31	.22
H46.3	152.0	B-7	S-32	.98
H46.5	152.5	B-7	S-33	.44
H46.6	153.0	B-7	S-34	.4
H49.4	162.0	B-7	S-35	.93
H49.5	162.5	B-7	S-36	1.0
H49.7	163.0	B-7	S-37	.15
H52.1	171.0	B-7	S-38	.5
H52.4	172.0	B-7	S-39	.27
H55.2	181.0	B-7	S-40	.65
H55.4	182.0	B-7	S-41	.5
H58.2	191.0	B-7	S-42	.38
H58.4	191.5	B-7	S-43	.98
H58.5	192.0	B-7	S-44	.47
H58.7	192.5	B-7	S-45	.43
H59.0	193.5	B-7	S-46	.24
H61.0	200.0	B-7	S-47	1.0
H61.1	200.5	B-7	S-48	1.1
H61.3	201.0	B-7	S-49	.45
H66.6	218.5	B-7	S-83?	.3
H66.8	219.0	B-7	S-54	.1
H69.8	229.0	B-7	S-57	.45
H70.0	229.5	B-7	S-58	.23
H70.4	231.0	B-7	S-59	.9

H70.6	231.5	B-7	S-60	.9
H70.7	232.0	B-7	S-61	.24
H72.8	239.0	B-7	S-62	.9
H73.0	239.5	B-7	S-63	.9
H75.9	249.0	B-7	S-65	.23
H78.9	259.0	B-7	S-68	.9
H82.0	269.0	B-7	S-70	.9
H82.1	269.5	B-7	S-71	.23
H85.0	279.0	B-7	S-73	.9
H85.2	279.5	B-7	S-74	1.0
H85.3	280.0	B-7	S-75	.21
H88.1	289.0	B-7	S-76	.9
H88.2	289.5	B-7	S-77	.3
H91.1	299.0	B-7	S-79	.47
H94.2	309.0	B-7	S-81	.9
H94.3	309.5	B-7	S-82	.32
H97.2	319.0	B-7	S-84	.18

Table II-11. Proportion of boreholes sampled. Nominal weight (kg) = $D\pi r^2 L/1000$ where D = mean density (1.73), r = 3.175 cm, and L = length in cm.

Borehole	Total Sample Weight (Kg)	Length (Ft)	Length (Cm)	Nominal Weight (Kg)	Total Sample Wt./ Nominal Weight = %
A	29.16	236.5	8034	432.5	6.7
B	36.46	299.5	9131	491.6	7.4
C	50.82	355.5	10228	550.7	9.2
D	28.82	322.0	9817	528.5	5.5
E	18.71	386.3	8728	469.9	3.9
F	38.82	328.8	10022	539.6	7.2
G	22.61	317.5	9679	521.1	4.3
H	34.49	315.0	9603	517.0	6.7

III Lithostratigraphy and phosphorite pellet concentration of TACTS cores A-H, and AMCOR drillhole 6002

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Tables III-1-11 provide the lithologic descriptions for the Savannah Offshore drillhole, Tacts boreholes A-H and AMCOR Hole 6002. The information given is based on visual descriptions using a binocular microscope, along with supplementary use of acid and the qualitative phosphate test (50% nitric acid and saturated ammonium molybdate, giving yellow color). The information on AMCOR Hole 6002 was taken from previous data of the Atlantic Margin Coring Project (AMCOR) of the U.S. Geological Survey (Hathaway and others 1976, and unpublished data on file at the USGS offices in Woods Hole, Mass.). Figures III-1-15 display the lithology, the pellet concentrations, and the stratigraphy of the boreholes mentioned above. All stratigraphic units for the TACTS cores were determined by P. Huddlestun on the basis of foraminiferal zones. Stratigraphic picks of boundaries between sampled zones are arbitrarily assigned.

The phosphorite pellet concentrations of TACTS Boreholes A-H were visually estimated by counting pellets within a 100-cell grid area as described in Ch. IV. Comparison with chemical data is facilitated by volumetric to weight/weight unit conversion factors provided in Chapter V. We used composite analyses of pure carbonate fluorapatite apatite from marine phosphorites in the North Carolina area as a standard reference material (Van Kauwenbergh and McClellan, 1985). Color was judged by eye and grain-size estimates were made wet under the microscope. Sizes are referred to the standard Wentworth size ranges. Clay denotes unconsolidated material, whereas shale indicates partial consolidation and incipient fissility.

Phosphorite pellets were found in matrices of all lithologic types: sand, silt, shale and clay, and carbonate. However, the highest concentrations were observed at unconformities where interfaces of several lithologies are found. Lowest concentrations were observed in sediments that had high concentrations of calcium carbonate. The pellets in most strata were generally brown-black, vitreous ovoids, often having consistent grain diameters in the range of 0.1 to 0.3 mm. Larger grain aggregates, often with gray-black color, were especially noted in Lower and Upper Pleistocene sediments, but larger aggregates could be found in many of the phosphate-rich horizons. As described in Ch. IV, it is assumed that the presence of phosphorite pellets in their characteristic size modes within finer-grained sediments is an indicator of primary pellet origin. Darker, oolitic or overgrown or aggregated pellets are regarded as having been subjected to reworking and secondary growth.

The phosphatic nature of the pellets was verified by qualitative chemical tests whenever there was uncertainty during visual analysis. However, some pellets may contain extraneous material, i.e., calcium carbonate, silicates or voids, although pellets had a nonporous, vitreous appearance, suggesting low water content.

The silts and clays of the main Middle to Lower Miocene formations were characterized by olive-green silts and clays having significant foraminiferal content, both benthic and pelagic. Glauconite was frequently present in trace quantities. Dolomite was frequently present but has not been systematically reported here.

The lines representing phosphate peaks on the profiles showing phosphorite pellet concentrations were generally baseline at midpoints to the next data points. This tends to reduce exaggeration of peak importance (width) where samples are sparse, but exaggeration may remain in many cases. In other cases, however, unrecorded peaks may exist where we had no sample coverage. The lithologic symbol pattern has been chosen on a "best estimate" basis for the most part, but in some areas, white space denotes uncertain lithology.

Organic- and uranium-rich phosphatic sediments

Phosphatic sediments at the Lower Pliocene and Middle Miocene unconformity were often dark and organic-appearing, whether they were in clays, silts, or sands. Further, many emitted a petroleum-like smell upon acid addition. This corresponds to a finding of tarry substance in correlative strata from the J-2 well (Charm and others, 1969; see also further comments in Ch. V).

A limited number of organic carbon measurements and indirect indicators suggest that the phosphatic Neogene sediments generally contain between 1 and 5% organic carbon, above average for offshore sediments Emilianov and Romankevich, 1987, but below concentrations of organic carbon reported for other strata, such as the Western Phosphoria deposits (Cathcart et al, 1984, and references cited).

Gamma logs have long been utilized to prospect for phosphorite on land (e.g. Furlow, 1969, and references cited). Uranium is the principal gamma emitter in phosphate-rich strata (Altschuler et al, 1958). Unfortunately, no gamma logs were available for the TACTS cores. However, a replotting of a gamma log available for AMCOR site 6002 (Fig. 11) provides what may be the closest approximation to a continuous estimation of phosphate content in shelf strata off Georgia. It reveals that the sparse distribution of earlier sampled strata in the AMCOR log (Hathaway et al., 1979) provided a very incomplete record of phosphate content of this site - especially in the Oligocene. The gamma log did not extend high enough to shed light on the Plio-Pleistocene in this borehole. Because of close sampling the combined volumetric and chemically analyzed samples provide a more detailed coverage, but major gaps are unavoidable.

Other phases

Gypsum in the form of shining crystals was frequently found in the samples, especially those that were dried out. This finding cannot be due to evaporation of pore water because gypsum can exceed in bulk the sulfate (<0.27% SO_4 in seawater) that could be supplied in original porosity. Given the probable subaereal exposure of some upper strata during Pleistocene emergence, formation of localized evaporitic lagoons with gypsum formation in Pleistocene time could be envisioned. However, the fact that the presence of gypsum is well correlated to drying of samples, microrupturing of sediment structure by small crystal balls after the core was recovered, and the brilliant, unleached quality of crystallites all point to its main origin as an artifact. Thus, we presume that most gypsum would be due to postsampling decomposition of iron sulfide (pyrite), its oxidation and subsequent reaction of the sulfuric acid formed from sulfide with local carbonate. The especial corrosion of carbonates in some of the high-gypsum samples supports this conclusion.

Discussion and conclusions

Examination of the lithostratigraphic profiles (Figures VI-V15) demonstrates several key points:

1) Phosphate-enriched strata are particularly associated with unconformities, especially at the Middle Miocene - Lower Pliocene boundary in the northern part of the area, and in successively deeper horizons to the south offshore Florida (J-1) (Figs III-12 and III-13).

2) Phosphate-enriched strata are rare in fine-grained sediments, especially carbonates, but occur preferentially within sandy zones. They and strata as a whole tend to be discontinuous and irregular over the distances of the order of the TACTS boreholes (30 km), a relationship readily explained by the fluctuation in sedimentation conditions accompanying multicycle transgressions and regressions documented in seismic profiles (Popenoe, 1991).

3) No systematic coast-to-outer-shelf trend in concentration of phosphorite phosphatic strata was observed. This is explained by the relationship of highly-enriched beds to eroded and reworked strata as revealed in the seismic profiles. An estimate of total phosphate content and trends within strata is made difficult by the fact that the TACTS cores sampled less than 10% of total penetrated strata. Yet the present data apparently provides the most comprehensive deeper (drill core) collection of samples in phosphatic strata made public to date. As such they warrant additional study.

4) Most of the deeper phosphatic horizons are below maximum currently feasible depth for dredging of mineral deposits (Popenoe et al., 1991). This and the environmental considerations involved in dispersal of large quantities of sediments during a deép dredging operation call attention to the experimental borehole mining technique discussed in the Introduction, should the economic potential of the deposits and future resource conditions warrant exploitation. However, borehole mining requires overlying strata strong enough to support temporarily mined and empty cavities. Fig. 15, depicting the schematic distribution of strata from the middle shelf and outward, suggest that such strata are mainly to be found in fine-grained Lower Pliocene to Middle Miocene strata - themselves potential phosphate-bearing zones. It is also possible that locally, Pleistocene carbonates may be sufficiently consolidated to offer geotechnically suitable foundation materials, but the poor recovery of samples in these strata does not provide adequate information to resolve this question.

5) As noted in Chapter IV, the presence of primary phosphorite in post-Middle Miocene strata, possibly even in later sediments, was indicated by new criteria for evaluating primary phosphatization. Workers studying the offshore phosphates of North Carolina (Riggs et al, 1990; Snyder et al, 1990)

report that transgressive sedimentation sequences extend to the Lower Pliocene in that area. The fact that the lithology of the Middle Miocene and lower Lower Pliocene are almost indistinguishable in the offshore Georgia area, suggests that the Lower Pliocene may form an important belt of primary phosphate-bearing sediments off many of the southeastern U.S. states. Reworking of these deposits may form phosphate enrichments higher in the geologic section and over much larger areas than previously realized.

6. Popenoe et al (1987 and Ch. VI) provide evidence that both onshore and offshore Georgia phosphorites may have been deposited in a trough in contrast to sediments deposited offshore and onshore in Florida and South Carolina to the south and the north. Primary phosphatization evidences in these strata (Ch. IV) seem to be restricted largely to finer-grained sediments. The deeper water during and after deposition may help explain the remarkable preservation of primary phosphatization in the TACTS sequences.

Table III-1: Lithologic description of TACTS borehole A. Sample color refers to eye appearance of naturally moist material. Description by binocular microscope with assistance of 10 % HCl, and qualitative molybdate test for phosphate. Mention of "some carbonate" refers to minor admixture to 25 % " carbonate sand denotes > 50 % carbonate. Sizes are based on Wentworth Scale (1922). For details of phosphorite pellet distribution see Appendix 1.

USGS Sample ID	Feet	Description
A1.1	3.5	Sand, gray-buff, very fine to coarse, poorly sorted, shell fragments, phosphorite grains .1-.2 to 1mm, phosphorite <1 - 2 % .
A1.9	6.2	Sand, gray, very fine to coarse, poorly sorted, very little sample.
A2.2	7.2	As above, very little sample left.
A2.9	9.5	Silty sand, gray, very fine to coarse, poorly sorted, shell fragments, sample cemented in jar, phosphorite 1-]2%, pellets ranging from .1- 2mm.
A3.4	11.0	Silty carbonate sand, light olive, very fine to very coarse, poorly sorted, < 1 % phosphorite.
A4.6	15.0	Silty carbonate sand, gray, very fine to coarse, poorly sorted, shell fragments, sample cemented in jar, very little phosphorite ~1 %.
A6.6	21.5	Carbonate sand, gray, medium coarse, poorly sorted, sample cemented in jar, phosphorite 3 - 5 %.
A7.2	23.5	As above, silty, highly phosphatic, petroleum smell upon acid application, phosphorite 4 - 5%.
A8.4	27.8	No sample remains in jar.
A9.3	30.5	As above, phosphatic, phosphorite 4 - 6 %.
A10.5	34.5	Very silty carbonate sand, olive-black, very fine to medium grain, poorly sorted, phosphorite 3 - 4 %.
A17.2	56.5	Sand, black-olive, fine to medium, well sorted, phosphorite 1 - 3 %.
A17.4	57.0	Silty sand, black-olive, very fine, well sorted, phosphorite 4 - 9 %.
A17.7	58.7	Sand, black, fine, well sorted, phosphorite ~ 8 % .
A20.6	67.5	Sandy silt, black, very fine, well sorted, phosphorite ~

8 %.

A24.4	80.0	Silty clay, olive-brown, fine, well sorted, with one small section of phosphatic sand, silty clay demonstrates no phosphorite, but matrix gives test.
A25.9	85.0	Silty sand, olive-brown, fine, well sorted, phosphorite 1 - 6 %.
A26.0	85.5	As above, olive-green, highly phosphatic, phosphorite 10 - 12 %.
A26.1	85.5	Silt, gray, fine, well sorted, phosphorite ~ 7 %.
A26.2	86.0	As above, phosphorite ~ 4 %.
A27.4	90.0	Carbonate sandy silt, tan with black, fine, well sorted, phosphorite 5 - 11 %.
A27.6	90.5	Silty sand, dark brown, medium, well sorted, some carbonate material, phosphorite 5 - 15%.
A30.2	99.0	Silty clay, dark brown, very fine, well sorted, no visible phosphorite, matrix gives test.
A30.3	99.5	As above.
A33.1	108.5	Silty sand, dark brown, fine to medium, fairly well sorted, some carbonate, phosphorite 9 - 10 %.
A33.2	109.5	As above, some phosphorite.
A33.4	109.5	As above, ~ 4 % phosphorite.
A36.6	120.0	Silt, dark brown, fine, well sorted, some forams, phosphorite 1 - 4 %.
A36.7	120.5	Silty clay, light brown, fine, well sorted, some phosphorite pellets.
A39.6	130.0	Sand, light brown, medium, fairly well sorted, phosphorite 7 - 20 %.
A39.7	130.5	Silty sand, light olive, fine to medium, poorly sorted, forams, phosphorite 8 - 25 %, various sized grains.
A39.8	130.5	Silty sand, light brown, fine, fairly well sorted,various size brown phosphorite pellets, phosphorite ~ 21 % .
A39.9	131.0	Silty clay, dark brown, fine, to medium, fairly well sorted, forams, highly phosphatic, various sized pellets, phosphorite 11 - 15 %.

A42.6	140.0	Clay, light brown, fine, well sorted, phosphorite < 1%.
A42.8	140.5	Silt, dark brown, fine, well sorted, phosphorite 3 - 5 %, dolomite?
A45.1	148.0	Silty clay, brown, fine, well sorted, < 1 % phosphorite.
A45.3	148.5	As above.
A48.0	157.5	As above.
A48.2	158.0	As above.
A48.6	159.5	Clayey silt, olive-brown, fine, well sorted small phosphorite pellets < 1%, matrix gives test.
A51.2	168.0	Silt, buff, fine, well sorted, phosphorite, 1 - 2 %.
A51.4	168.5	Silty clay, light brown, fine, well sorted, carbonates, phosphorite < 1 %.
A51.7	169.5	As above with foraminifera, phosphorite < 1%.
A54.6	179.0	Silty clay, light brown, fine, well sorted, some carbonate, phosphorite < 1 %.
A54.7	179.5	As above, phosphorite 1 - 3 %.
A54.9	180.0	As above, foraminiferal, phosphorite 1 - 3 % pellets to 1 mm .
A57.1	187.3	As above, buff, phosphorite < 1% .
A58.2	190.8	As above, light brown, matrix gives test.
A60.0	197.0	Silt, olive-gray, fine, well sorted, very little phosphorite, highly foraminiferal, < 1% phosphorite.
A60.4	198.0	Silty clay, light brown, fine, well sorted, carbonates, phosphorite < 1 %.
A61.1	200.5	As above, olive, phosphorite < 1%.
A62.7	206.0	As above, phosphorite, < 1%.
A62.8	206.0	Silt, tan, fine, well sorted, phosphorite <1%.
A62.9	206.5	Silt, olive-gray, fine, well sorted, little phosphorite < 1%, matrix gives test.
A65.8	216.0	Carbonate /quartz sand, brown, medium, fairly well sorted, phosphorite 1-3%, some forams.

A66.0	216.5	As above, some silt, gray, phosphorite 1-2%.
A66.1	217.0	As above, phosphorite <1%.
A68.6	225.0	As above, carbonate silt, gray, phosphorite <1%, one phosphorite pellet 2-3 mm, gives petroleum smell when tested.
A72.1	236.5	Carbonate sand, tan, medium to fine, well sorted, phosphorite 1-2 %, glauconite.
A72.2	237.0	As above, phosphorite ~ 3 %, glauconite.
A81.4	267.0	Carbonate sand, cream, fine to medium, well sorted, phosphorite < 1%.

Table III-2. Lithologic description for TACTS Borehole B. Sample color refers to original sample observed by eye. Other description is by binocular microscope with assistance of 10% HCl, and qualitative molybdate test for phosphate. Textures are based on the Wentworth scale (very coarse 1-2, coarse .5-1, medium .25-.5, fine .124-.25, very fine .0625-.124, silt 1/16-1/256, clay <1/256mm). No effort was made to distinguish dolomite from other carbonate. Phosphate abundance estimated under microscope visually as discussed in text.

USGS Sample ID	Feet	Description
B0.2	0.5	Sand, white, poorly sorted, coarse to pebbles >10mm. Some coarse carbonate debris with scarce phosphorite pellets. Phosphorite pellets are black, polished and large, 0.5-0.7mm
B2.4	7.8	Sand, white-light buff, well-sorted, fine, liberally sprinkled with intense black particles having an irregular rough outline, generally non-phosphatic, but sample as a whole gives test for small amount of phosphate admixture. Very little sample remains
B3.0	10.0	Sand, buff, very poorly sorted, very coarse to fine with clasts of sand cemented and filled with gray-olive clay and silt. Phosphorite grains ~ 1.0% mostly normal pellet size (.2-.3mm) plus a few large, rounded impure grains to 0.7mm
B3.1	10.0C	As above without clay clasts
B3.2	10.5	As above, with rusty (secondarily altered), somewhat finer-grained. <=1% phosphorite, dark black-greenish; large brownish angular grains often do not test positively for P; large pectin shell fragment
B4.1	13.5	Sand, buff, coarse-very coarse with cemented silty-carbonate containing grains; these contain black oval grains about .5mm, phosphatic in part
B5.0	16.5	As above
B7.9	26.0	Rubbly pebble-sized shell hash, varicolored, highly cemented in bottom of jar. Colors range from white to buff, orange to deep red-brown-gray black; dark gray-black lumps seem to have much dispersed organic matter and give off petroleum smell on application of acid; no phosphate. Cementation has taken place post sampling
B9.1	30.0	Sandy shell hash with rounded carbonate concretionary pellets, .5-5mm, with much fine carbonate. Rounded black

		grains .5-1.5mm contain fine silt-size black particulate matter, partly phosphatic. Remaining sample cemented in bottom of jar
B10.0	33.0	Carbonate sand, quartz-rich; quartz ranges from medium-coarse whereas carbonate ranges from much larger shell fragments and cemented grains to finer material. Many dark gray-black particles but most are non-phosphatic; phosphorite pellets (scarce) are round and shiny
B12.2	40.0	Carbonate sand, orange-stained from corrosion of steel fragment; few round black phosphorite pellets and large piece of razor clam-like shell with outer honeycomb framework exposed by corrosion
B12.8	42.0	Sand, gray shelly, coarse; pelecypod shell bored by gastropod, gray pepper & salt rounded fragments, 1-1.5mm, much very fine carbonate < 1mm-30um; little visible phosphorite, but sample as a whole shows phosphate test
B14.6	48.0	Sand, gray, carbonate rich, medium-coarse with white weathered mollusc shell fragments and black carbonate grains, non-phosphatic.
B20.9	68.5	As above, with mollusc shells to 12mm filled with cemented sandy carbonate mudstone mold, hard, speckled with darker carbonate fragments. Does not readily crumble apart as with superficial post-sampling cementation
B24.6	79.0C	Silt, dark chocolate-brown, well sorted, and foraminiferal with many tests mere residual fragments of test that has been largely dissolved away; highly phosphatic, 30-50%
B24.7	81.0C	Silt, clayey to fine-sandy, dark brown-chocolate with abundant phosphorite pellets making up nearly all sand-sized material, forams (planktonic) abundant; phosphorite 20-40%
B24.8	81.5	Phosphorite sand, dark brown-black, .2-.3mm, slightly silty-clayey but these fractions are also dark with less frequent quartz sand grains and very rare forams. Phosphorite 60-70%, but only about 10g. sample left
B30.6	100.5	Shale, dark-brown, highly foraminiferal, phosphatic, organic-rich, petroleum smell on applying acid; under high magnification shell matrix itself has a spherultic appearance as though spherulites were molds of planktonic foraminifera. Pelletal material makes up 5-10% of sample
B31.1	102.0	Silty clay, buff with darker layer characterized by admixture of typical phosphorite pellets, highly foraminiferal, 15-20% phosphorite pellets
B31.1	102.0	Silty clay, olive, with sand-sized pellets (5-8%) and sparse

		carbonate tests
B34.0	111.5	Clay, olive-green, foraminiferal; no pellets visible but clay matrix is phosphatic
B37.2	122.0	Silty to sandy clay, olive, with phosphate pellets and some carbonate fragments; pellets are irregular in shape, 7-10%
B37.3	122.5	Clayey siltstone, buff-olive, poorly consolidated with sand size white carbonate consisting in part of pellet size forams, largely mixed in origin. Few pellets arevisible but matrix gives phosphate test
B37.5	123.0	Clay, olive-green, few obvious microfossils and no pellets but matrix is slightly phosphatic
B40.1	131.5	Clay, olive-buff, silty with abundant carbonate fragments
B40.4	132.5	Clay, olive well-consolidated with many discoid diatom frustules, about .25mm; tend to disappear after acid treatment; pellets <1%
B43.3	142.0	Clay, olive. sparse fauna, some diatoms, very sparse pellets but matrix yields positive P-test
B46.3	152.0	As above
B49.2	161.5	As above, slight gasoline smell on application of 10% HCl
B49.5	162.5	As above, slightly silty
B52.4	172.0	Clay, olive, diatomaceous
B52.6	172.5	As above, dried sample shattered by gypsum growth
B52.8	173.0	As above, scarce brownish particles
B55.8	183.0	Shale, diatomaceous, olive, intercalated with shale having about 3% pellets; much gypsum. Carbonate tests can be observed to be replaced and filagreed by gypsum
B61.6	202.0	Shale, silty-sandy, dark brown-olive phosphatic with pellets as well as many benthic foraminiferal tests
B64.6	212.0	Shale, light olive, very sandy with carbonate microfossils; few pellets but matrix gives test
B67.8	222.5	Clayey siltstone, buff-olive, white speckled with frosted carbonate tests; no pellets but gypsum growth
B70.6	231.5	Shale, olive-white speckled with high foraminiferal content

B73.2	240.0	Siltstone, sandy olive, speckled with white foram tests, some large Uvigerina-like specimens. No phosphate
B73.8	242.0	Shale, silty to sandy, olive with white mixed foram and micromollusc(?) fauna; very small, scarce phosphorite pellets
B76.5	251.0	Siltstone, clayey to sandy, olive, with abundant benthic foram tests and scattered pellets; rock disaggregates to rounded buff masses, partly phosphatic, that have similar size and shape as some benthic forams, to 1.2mm - protophosphorite?
B79.4	260.0	Siltstone, olive, well sorted with diatom frustules and occasional phosphorite pellets
B82.6	271.0	Shale, olive drag, silty-sandy with white sprinkles of benthic forams and ostracods(?)
B85.0	279.0	Shale, olive-green homogeneous; foram tests not visible to the naked eye, but appear under microscope
B85.6	281.0	Shale, sticky clayey, olive-green sparse fauna
B88.2	289.5	Shale, olive-green, abundant foram tests but many have been converted to filagrees of gypsum
B88.4	290.0	Shale, dark olive-green, gritty with abundant corroded and friable foram and microfossil tests. This specimen underwent considerable drying
B91.1	299.0	Sand, olive calcareous with near micrococquina of benthic forams, 1% phosphorite pellets
B91.4	300.0	Sand, olive-buff, fine-silty with white specklings of benthic foram tests and sparse phosphorite. Gasoline smell upon applying acid; dissolution of benthic foraminifera tests reveals many tiny pellets in chambers

Table III-3: Lithologic description of TACTS borehole C. Others notes as in Table Xa.

USGS Sample ID	Feet	Description
C0.2	0.5	Sand, light brown, medium to coarse, poorly sorted, shell fragments, phosphorite <1%.
C3.2	10.5	Sand, gray, medium to coarse, poorly sorted, shell fragments, phosphorite < 1 %.
C4.1	13.5	Sand, gray brown, as above.
C5.0	16.5	As above.
C5.3	17.5	Clay, burnt orange-gray, fine, well sorted, no phosphorite.
C5.6	18.5	Sand, gray, medium, fairly well sorted, shell matter, phosphorite 2 - 3%
C6.6	21.5	As above, phosphorite 1 - 2 %.
C7.8	25.5	Sand, gray, medium to very coarse, poorly sorted, shell fragments, phosphorite < 1- 1 %.
C8.7	28.5	Carbonate/quartz sand, gray-buff, fine to coarse, poorly sorted, phosphorite, 1 - 3 %.
C9.3	30.5	Silty carbonate sand, gray, fine to medium, fairly well sorted, phosphorite ~ 9 %, possible dolomite.
C10.4	34.0	As above, phosphorite ~ 5 %.
C11.3	37.0	Silty sand, brownish, very fine to fine, fairly well sorted, forams, phosphorite ~ 9 %.
C12.2	40.0	Silty clay, olive, fine, well sorted, phosphorite < 1 %, matrix gives test, few visible pellets.
C14.0	46.0	As above, dark olive.
C14.8	48.5	Silty sand, olive, fine to medium, fairly well sorted, little phosphorite.
C17.7	58.0	Silty clay, olive, fine, well sorted, phosphorite 1 - 3%.
C17.8	58.5	Silty clay, olive brown, fine, well sorted, phosphorite 1 %.

C18.0	59.0	As above, phosphorite 1 - 2 %.
C20.7	68.0	Silty sand, dark olive, fine to medium, well sorted, phosphorite ~ 12 %.
C20.9	68.5	Silty sand, olive black, fine, well sorted, phosphorite 15 - 19 % .
C21.0	69.0	Silty clay, sea green-black, fine, well sorted, phosphorite 4 - 7 %.
C23.8	78.0	Silty clay, olive, fine, well sorted, phosphorite < 1 %.
C23.9	78.5	Silty clay, olive, fine, well sorted, phosphorite < 1 %, matrix gives test.
C24.1	79.0	As above.
C26.4	86.5	Silty clay, olive, dark brown, medium, well sorted, phosphorite 13 - 15 %.
C26.7	87.5	Slightly silty sand, brown, medium, well sorted, highly phosphatic.
C26.8	88.0	Silty sand, black brown, fine to medium, fairly well sorted, some carbonate.
C29.1	95.5	Sand, black brown, medium sorted, phosphorite ~ 13 %.
C29.3	96.0	Clayey sand, dark olive/dark brown, fine to medium, fairly well sorted, phosphorite ~ 17 %, dolomite.
C32.3	106.0	Silty clay, olive-brown, fine, well sorted, phosphorite < 1 %, matrix gives test.
C32.5	106.5	Clay light brown, fine, well sorted, phosphorite < 1 %.
C32.6	107.0	As above, some carbonate, no phosphorite, matrix gives test.
C35.1	115.0	Silty clay, olive-brown, fine, well sorted, phosphorite < 1 %, matrix gives test, some forams.
C35.2	115.5	Clay, olive gray, fine, well sorted, some carbonate, phosphorite < 1 - 1 %.
C35.4	116.0	As above, dark brown.
C37.2	122.0	As above.
C37.3	122.5	As above, light brown, less carbonate.

C37.5	123.0	As above, brown, matrix gives test.
C40.5	133.0	Silty clay, dark brown, medium, well sorted, phosphorite 9 - 17 %.
C40.7	133.5	Very silty carbonate sand, dark olive-brown, fine to coarse, poorly sorted, glauconite, phosphorite 4 - 12.
C40.8	134.0	Silty phosphorite sand, dark brown, medium fine, phosphorite ~ 10 %.
C43.9	144.0	Clay, light brown gray, fine, well sorted, phosphorite < 1%.
C44.0	144.0	As above, some carbonate.
C46.6	153.0	As above, light olive.
C50.1	164.5	As above, brown, carbonate material.
C50.3	165.0	As above, brown gray, some carbonate.
C53.3	175.0	Silty clay, olive, fine, well sorted, forams, phosphorite < 1 %, matrix gives test, glauconite.
C53.5	175.5	As above, more carbonates.
C53.6	176.0	As above.
C56.4	185.0	Silty clay, olive, fine, well sorted, phosphorite < 1 %.
C56.5	185.5	As above, light brown, ~ 1 % phosphorite.
C56.7	186.0	As above, light olive.
C59.4	198.0	Very silty carbonate sand, dark olive-brown, fine to coarse, poorly sorted, small phosphorite pellets 1 - 3 %, glauconite.
C59.6	195.5	Silty sand, tan, fine to coarse, poorly sorted, forams, 1 - 3 % small phosphorite pellets and phosphorite pellets to 5 mm.
C59.7	196.0	Carbonate silty sand, light brown, fine to medium, poorly sorted, small phosphorite pellets, also phosphorite pebbles, glauconite, phosphorite 2 - 4 %.
C62.2	204.0	Silty carbonate sand, olive, medium, fairly well sorted, glauconite, phosphorite < 1 %.
C62.3	204.5	As above, buff cream, phosphorite < 1 %.

C62.5	205.0	Silty carbonate sand, light brown, fine to medium, well sorted, phosphorite < 1 %.
C65.2	214.0	As above, very silty.
C65.4	214.4	As above.
C65.5	215.0	As above light brown.
C68.0	223.0	As above.
C68.1	223.5	As above.
C68.3	224.0	As above, forams.
C71.6	235.0	As above.
C71.8	235.5	As above.
C71.9	236.0	As above, glauconite.
C73.8	242.0	As above.
C73.9	242.5	As above, glauconite, phosphorite ~ 1 %.
C74.1	243.0	As above.
C76.8	252.0	As above.
C77.0	252.5	As above, buff.
C77.1	253.0	As above, more clay, less forams.
C78.0	262.0	As above.
C80.0	262.5	As above.
C80.2	263.0	Carbonate sand, cream, medium-fine, fairly well sorted, glauconite, phosphorite <1 %.
C82.9	272.0	As above.
C83.1	272.5	As above.
C83.2	273.0	As above, light olive-tan, slightly silty.
C86.9	285.0	Clay, light olive, fine, well sorted, matrix gives test.
C87.0	285.0	Silty carbonate sand, cream, medium, fairly well sorted, no phosphorite.
C87.2	286.0	Clay, olive-tan, fine, well sorted, matrix gives test.

C89.8	294.5	Carbonate silt, tan, fine, well sorted, phosphorite < 1 %.
C96.0	315.0	Silty clay, olive, fine, well sorted, glauconite, phosphorite < 1 %.
C96.2	315.5	As above, olive-tan.
C96.3	316.0	As above.
C102.1	335.0	As above.
C102.3	335.5	As above, cream.
C102.4	336.0	Clay, tan-brown, fine, well sorted, phosphorite < 1 %

Table III-4. Lithologic description for TACTS Borehole D. Other notes as in Table III-1.

USGS Sample ID	Feet	Description
D0.3	1.0	Quartz sand, white, clean, subrounded, medium to coarse with 10% carbonate fragments and <3% brown-black phosphorite grains
D0.7	2.4	Sand, gray-white, subangular to subrounded, medium-coarse, with light to dark gray carbonate fragments .5-4 mm , and 2% phosphorite grains, about .2 mm in diameter; quartz grains are mixed clear and frosted grains
D1.5	5.0	Quartz sand, shelly (gastropod fragments), poorly sorted, silty to coarse, 3% dark phosphorite grains; larger dark-green carbonate fragments are non-phosphatic and may be blackened shell
D2.7	9.0	Sand, very shelly (40-50%), fine to medium, mainly clear subrounded quartz; carbonate grains grade much finer: <1% phosphorite grains
D4.3	14.0	Two phases 1) sand, gray, shelly with highly frosted and recrystallized / leached gray carbonate grains; quartz is fine to medium (0.1-.5%) grains; 2) 2 balls of hard, shelly sandstone, similar texture as above; not certain whether 3 cm lumps are lithified in situ or after sampling
D5.2	17.0	Sand, buff, highly shelly, fine-medium, with white medium-coarse carbonate with a greater spread of textures (<.05-1.5 mm); some concretionary lumps 1-5 mm; 3% black phosphorite grains, .1-.3 mm
D6.9	22.5	Sandy calcarenite, buff-olive, partly cemented, fine-coarse (.2-.8 mm), 2% black-brown phosphorite grains, .2-.3 mm
D8.8	29.0	Calcarenite, buff-pale green, sandy in part, abundant benthic foraminifera, often partly altered and chalky in appearance; some cemented lumps, apparently natural, others questionable; carbonate size .2-3 mm, 3% dark brown-black phosphorite grains, angular
D9.4	31.0 31.5	Sand, brown shelly, phosphatic, fine-coarse, shell to 2 mm; both fresh and altered carbonate; much rusty-stained quartz(source of color), 6-10% phosphorite

D10.7	35.0	Quartz sand, dark brown, fine, well-sorted, non-carbonatic with streaks of carbonate-rich white sand, .03-.3 (silty-fine sand), 1-3% phosphorite pellets
D10.8	35.5	Sand, brown, highly phosphatic, shelly fine to coarse, many foram tests with adhering internal cemented molds; a few phosphate grains reach .4-.5 mm, unlike most pellets that maintain a consistent .2-.3 mm size
D11.6	38.0	Iron-encrusted and cemented sandstone, brown, with softer partly unconsolidated material inside; rusty to dark-brown clayey layer; mollusk and foram fragments, microgastropods and bryozoa also; few phosphorite pellets
D11.7	38.5	Sand, intense dark-brown, silty to fine, with occasional 1 mm quartz grain; 5% phosphorite made up of fine pellets .06-.1 mm
D14.2	46.5	As above
D17.8	58.5	As above, 3% larger phosphorite pellets, .1 mm
D21.3	70.0	Clay, dark-brown with sprinkling of phosphorite (1% in .1-.2 mm pellets)
D24.4	80.0	Sandy, very dark-brown, silty with clay admixture and occasional larger grains; sprinkling of foraminiferal tests; 6% phosphorite
D27.6	90.5	Clay, olive-brown with ooid-like specks, possibly planktonic globigerinids
D30.5	100.0	Clay, very dark with sprinkles of white planktonic? foraminifera and phosphorite; clay itself is phosphatic
D36.9	121.0	Clay, olive green, silty with up to 25% well-preserved foraminifera, some with phosphorite grains inside; some may have lodged there mechanically but primary grains are not excluded
D37.5	123.0	Clay, olive-green, highly foraminiferal, no visible phosphorite
D39.9	131.0	Clay, olive-green, foraminiferal
D44.2	145.0	Clay, olive, foraminiferal
D46.9	154.0	Clay, dark-brown, phosphatic, 20% gray phosphorite particles make up the principal coarse matter, followed by white foram debris

D47.1	154.5	Sand, olive, highly phosphatic, (25-30%) with sprinkling of foraminifera
D49.1	161.0	Sand, intense brown-black phosphatic with carbonate and clay admixtures; petroleum smell on HCl application; samples may contain up to 50% phosphorite if majority of light brown grains are phosphorite (random samples tested positively)
D53.0	174.0	Clay, olive-green
D61.7	202.5	Shale, olive, limy (dolomitic?) (decrepitates with the application of 10% HCl); sparse phosphatic fragments and pellets
D63.9	209.5	Shale, olive phosphatic-foraminiferal, 3-8% phosphorite pellets, standard .1-.3 mm size, carbonate plates and fragments 0.5-1.3 mm
D64.3	211.0	Shale, olive phosphatic with 3-5% carbonate fragments, 0.05-2 mm, including both benthic and planktonic foraminifera. Petroliferous odor on applying acid; 8-12% phosphorite
D70.0	229.5	Shale, dark olive foraminiferal, non-phosphatic
D3.3	240.5	Shale, olive foraminiferal with many multifaceted crystalline balls of gypsum, .3-.8 mm, a few with crossed fat crystals (.5 mm) not primary, probably caused by interaction of oxidized pyrite sulfur with carbonate; dried cores often have a rubble of shale fragments created by the expansion of the gypsum
D79.4	260.5	Calcarenite, light olive sandy, highly foraminiferal, with sprinkling of phosphate pellets; sand is <1 to 4 mm; petroleum smell released on acid treatment
D82.9	272.0	Calcarenite, brownish olive, fine sandy, foraminiferal, phosphatic with much light brown irregular phosphate in the form of coatings up to 1.5 mm and irregularly shaped pieces; phosphorite 5-20%
D85.8	281.5	Clay, olive, silty foraminiferal with fine phosphorite shown by chemical test (grains rare); 0.1 mm glistening gypsum crystals due to storage of core
D91.0	298.5	Clay, olive, foraminiferal, phosphatic with larger gray black 4 mm l rounded nodules, hard, some with hollow center; some silt and occasionally sand-gray. 3-6% phosphorite pellets
D98.3	322.5	Sand, olive, silty to clayey phosphatic; includes both

		standard .1-.2% brownish-black pellets, irregular larger gray-black rounded grains, 0.5-2 mm, and irregular brownish recrystallized phosphorite; total average 5%
D98.5	323.0	As above, much gypsum, less phosphorite but large phosphatic grains to 3 mm still present

Table III-5 :Lithologic description of TACTS borehole E

USGS Sample ID	Feet	Description
E5.5	18.0	Very silty clay, gray, fine to medium, fairly well sorted < 1% phosphorite, matrix gives test.
E10.7	35.0	Sand, some carbonate silt, white, gray, fine to medium coarse, poorly sorted, shell fragments, ooides, phosphorite < 1% - 1%.
E11.6	38.0	Silty quartz/carbonate sand, olive, fine to coarse, poorly sorted, shell fragments, phosphorite 1 - 2%.
E12.5	41.0	As above, light olive-tan.
E14.6	48.0	As above, more quartz.
E17.7	58.0	As above, fine to very coarse, phosphorite < 1 - 1 %.
E23.5	77.0	As above, light olive, possible dolomite, phosphorite 1 - 2 %.
E26.5	87.0	Silty carbonate sand, olive with black, fine to medium, poorly sorted, forams trace phosphorite.
E29.4	96.5	Silty carbonate, medium olive, fine to medium, poorly sorted, forams, phosphorite 1 - 15 %.
E29.6	97.0	Silty carbonate sand, olive, poorly sorted, forams, phosphorite pellets from .2 to 2 mm, trace phosphorite.
E32.6	107.0	Very silty sand, olive-black, some forams, trace phosphorite, ~.3 mm grains.
E35.7	117.0	Silty sand, brown, fine, well sorted, forams, matrix gives test, glauconite, phosphorite < 1 %.
E35.8	117.5	Quartz sand, olive, very fine, well sorted, phosphorite < 1% pellets .05 mm, very few forams.
E36.0	118.0	Silty sand, brown, very fine, well sorted, few forams, phosphorite < 1%.
E38.7	127.0	Sand, olive-brown, very fine, well sorted, phosphorite ~1%.
E41.8	137.0	As above, brown, silty.

E44.8	147.0	As above, trace phosphorite, with pellets to .3 mm.
E48.0	157.5	As above.
E48.2	158.0	As above, olive-buff, < 1% phosphorite.
E51.1	167.5	Silty sand, brown, fine, fairly well sorted, forams, phosphorite < 1%.
E54.4	178.5	Silty carbonate sand, light brown, very fine to fine, fairly well sorted, no visible phosphorite, matrix gives test, forams, glauconite.
E54.6	179.0	As above.
E57.8	189.5	Silt, high carbonate content, olive-brown, fine to medium, fairly well sorted, glauconite, phosphorite 1 - 3 %.
E57.9	190.0	Silty sand, buff-brown, fine to medium, poorly sorted, forams, glauconite, phosphorite pellets up to .7 mm, phosphorite ~ 2 %.
E60.7	199.0	Very silty sand, dark brown, very fine to fine, well sorted, phosphorite ~ 3%.
E60.8	199.5	Silty phosphorite sand, dark brown, fine to medium, poorly sorted, phosphorite 3 - 6 %.
E61.0	200.0	As above, phosphorite ~ 10 %.
E64.5	211.5	Silty clay, olive, fine, well sorted, < 1% phosphorite, matrix gives test.
E64.6	221.0	Silt, brown, very fine, well sorted, no visible phosphorite, matrix gives test, few forams, dolomite?
E67.2	220.0	Silty clay, olive, fine, well sorted, < 1% phosphorite, matrix gives test.
E67.4	221.0	Silt, brown, very fine, well sorted, no visible phosphorite, matrix gives test, few forams.
E91.6	300.5	Silty carbonate sand, olive tan, fine to medium, poorly sorted, phosphorite ~ 1 %.

Table III-6: Lithologic description of TACTS borehole F

USGS Sample ID	Feet	Description
F0.1	0.3	Carbonate sand, slightly silty, white, very fine to coarse, poorly sorted, few various size phosphorite pellets, < 1 %.
F0.2	0.5	Quartz sand, tan, some dark flecks, fine to medium, poorly sorted, shell frags., very little phosphorite.
F2.9	9.5	As above, silty.
F3.4	11.0	Quartz sand, gray, fine to coarse, poorly sorted, shell fragments, very little phosphorite, < 1 - 1 %.
F5.9	19.0	As above, phosphorite < 1 - 1 %.
F6.7	22.0	As above, slightly silty phosphorite <1 %.
F7.0	23.0	As above, very little sample left.
F8.0	26.1	As above, more carbonate material, ~ 1 %.
F10.1	33.0	Silty carbonate sand, buff, very fine to medium, poorly sorted, phosphorite 1 - 2 %.
F12.0	39.5	As above, more silt, phosphorite < 1 %.
F12.2	40.0	As above, phosphorite < 1 %.
F18.9	62.0	Sand, light brown, fine to medium, poorly sorted, phosphorite < 1 %.
F20.6	67.5	Silt some fine quartz sand, dark brown, very fine to fine, fairly well sorted, phosphorite < 1%.
F23.8	78.0	Quartz sand, dark olive, fine, well sorted, phosphorite 1.7 %.
F23.9	78.5	As above, silty, some carbonate, glauconite, phosphorite 1 - 2 %.
F27.0	88.5	Silty sand, dark brown, fine to medium, fairly well sorted, phosphorite 3 - 8 %, varicolored grains.
F30.2	99.0	Clay, chocolate brown, very fine, well sorted, very little visible phosphorite, matrix gives test.

F30.3	99.5	Clay, olive, very fine, well sorted, no visible phosphorite pellets, matrix gives test.
F33.4	109.5	As above, olive.
F36.3	119.0	As above.
F36.4	119.5	As above.
F39.3	129.0	Clay, olive, very fine to fine, fairly well sorted, forams, very little phosphorite.
F39.5	129.5	Clay, olive, white speckles, very fine to fine, fairly well sorted, forams, possible primary phosphorite pellets.
F42.7	140.0	As above, olive, less forams.
F42.8	140.5	As above.
F43.0	141.0	As above.
F45.7	150.0	As above.
F45.9	150.5	As above, very little phosphorite.
F46.0	151.0	As above, highly foraminiferal, pellets in foram tests.
F48.8	160.0	Sand, silty highly foraminiferal, olive-brown, very fine to medium, poorly sorted, phosphorite 2 - 7 %.
F48.9	160.5	As above, phosphorite 2 - 6 %.
F49.1	161.0	As above with glauconite, phosphorite 1 - 4 %.
F52.0	170.5	Quartz sand, silty, brown, fine to medium, poorly sorted, phosphorite 2 - 5 %.
F52.1	171.0	As above, phosphorite 3 - 5 %.
F55.0	180.5	As above, phosphorite 8 - 11 %.
F55.2	181.0	As above, pellets varicolored, phosphorite 5 - 15 %.
F58.1	190.5	Clay, olive, very fine, well sorted, no visible phosphorite, matrix gives test.
F58.2	191.0	As above.
F61.4	201.5	As above.
F61.6	202.0	As above.

F61.7	202.5	As above.
F64.0	210.1	Phosphorite crust, black, well cemented
F67.1	220.0	Silty quartz sand, light tan, phosphorite pellets, forams, very fine to medium, poorly sorted, phosphorite <1 - 3 %.
F67.2	220.5	As above, phosphorite < 1 - 5 %.
F67.4	221.0	As above, phosphorite < 1 %.
F70.1	230.0	Carbonate sand, light olive speckled black, very fine to medium, poorly sorted; HNO_3 dissolution yields many clear, reddish angular diffuse aggregates mostly clay, phosphorite <1 - 6 %.
F70.3	230.5	Sand, very silty, olive brown, very fine to medium, poorly sorted, forams, phosphorite 6 - 15 %.
F70.4	231.0	As above, phosphorite 4 - 6 %.
F72.8	239.0	Carbonate sand, silty, light olive, very fine to fine, well sorted, very small pellets, phosphorite < 1 %.
F73.0	239.5	As above.
F73.1	240.0	As above, a few larger pellets to .5 mm.
F75.9	249.0	Silt composed of carbonate, light olive, very fine to medium (pellets), poorly sorted, phosphorite 4 - 5 %.
F76.0	249.5	Carbonate sand, silty, light olive, very fine to medium, poorly sorted, phosphorite ~ 1 %.
F76.2	250.0	As above, phosphorite 11 - 13 %.
F78.9	259.0	Clay, light olive, very fine to medium, highly foraminiferal, very little phosphorite.
F79.2	259.5	As above.
F79.1	259.5	As above.
F81.7	268.0	Clay, olive, very fine, well sorted, very little phosphorite.
F81.8	268.5	As above, also some very fine phosphorite pellets.
F82.0	269.0	As above, no phosphorite, more carbonate.
F84.7	278.0	Silty carbonate sand, light brown, very fine to medium,

		some pellets up to .7 mm.
F84.9	278.5	Carbonate sand, foraminiferal microcoquina, olive, very fine to coarse, poorly sorted, phosphorite, ~ 3 %, pellets small.
F85.0	279.0	As above, phosphorite < 1 %.
F87.5	287.0	Clay composed of carbonate, olive brown, very fine, well sorted, very little visible phosphorite, matrix gives test, petroleum smell on acid application, forams.
F87.6	287.5	As above.
F87.8	288.0	Clay, chocolate brown, very little carbonate, matrix gives test.
F93.6	307.0	Carbonate, silty, light olive, forams, very fine to medium, fairly well sorted, layer of orange.
F93.7	307.5	Clay, olive, very fine to medium, (pellets) poorly sorted, few forams; well-laminated, abundant forams, dark brown, phosphorite concentrated in coarser lenses with sand, 5.5, sugary buff dolomite balls 1.0 andother shapes, also crystalline gypsum; phosphorite 4 - 9 %.
F99.8	327.5	Carbonate lutite, olive, very fine to medium, well sorted, forams, very little phosphorite.
F100.0	328.0	Microcoquina, olive, foraminiferal, quartz sandy, a few large phosphorite grains, aggregate particles.
F100.1	328.5	Silty carbonate sand, light olive, fine-very fine, well sorted, phosphorite < 1 %.
F100.3	329.0	As above, forams, phosphorite < 1 - 4 %.

Table III-7: Lithologic description of TACTS borehole G.

Sample	USGS ID	Feet	Description
	G0.3	1.0	Quartz sand, gray speckled, medium coarse.
	G0.9	3.0	Quartz sand, black speckled, medium angular - sub-angular, clean with broken mollusce shells -> 5mm white to black.
	G1.8	6.0	Quartz sand, white, medium with coarser grains to 1.5 mm, and occasional carbonate fragments, some blackened mollusc shell fragments (non-phosphatic).
	G2.7	9.0	Quartz sand, light gray black speckled, fine to medium, rounded to subangular.
	G4.3	14.0	Quartz sand, gray slightly greenish, fine.
	G4.9	16.0	Quartz sand, gray-olive, fine to very fine, with abundant (10%) carbonate fragments (also siliceous spicules) benthic forams common; many multicolored grains, orange, green, amber; variable fauna.
	G5.0	16.3	Silty quartz sand, light gray, very fine to medium, poorly sorted, shell fragments.
	G5.2	17.0	Silty clay, gray,with fine - very fine sand, with .2-.5 mm spicules, black, plate to lath-shaped vitreous matter, not necessarily phosphatic, multicolored fragments, fine- very fine size, green, reddish, amber, much degraded carbonate, foraminiferal, no pellets.
	G5.6	18.5	Shale, dark gray-brown with gray-white streaks, fine-very fine sand, speckled with amber organic matter micro mollusc (1.5 mm), and forams, benthic, mica .230 diam.
	G5.8	19.0	Silt, some quartz sand, dark gray, very fine to very coarse, poorly sorted, shell fragments, phosphorite <1 %.
	G6.4	21.0	Quartz sand mixture, multicolored - black, cream, rust, yellow, very fine to coarse, poorly sorted, shell fragments, organics, very little phosphorite.
	G7.6	25.0	Silty carbonate/quartz sand, gray, very fine to coarse, poorly sorted, phosphorite < 1 %.
	G8.5	28.0	Carbonate/quartz sand, light gray, fine to coarse,

		poorly sorted, phosphorite ~ 1 %.
G9.3	30.5	Silty carbonate/quartz sand, buff, very fine to coarse, poorly sorted, phosphorite, < 1 - 1 %, pellets poorly sorted.
G10.7	35.0	Slightly silty, quartz sand, light gray, fine to medium, fairly well sorted, some forams, phosphorite ~ 2 %.
G11.3	37.0	Slightly silty sand, gray-olive, black speckles, very fine with coarse shell material, phosphorite < 1 - 2 %.
G14.0	46.0	Quartz sand, dark olive-black, medium, well sorted, phosphorite 1 -2 %.
G17.1	56.0	Slightly silty, quartz sand, dark olive, fine to medium, fairly well sorted, phosphorite 3- 4 %.
G19.8	65.0	Quartz sand, brown-gray, medium, well sorted.
G22.9	75.0	Quartz sand, olive-black, fine, well sorted, phosphorite 3%.
G25.9	85.0	Quartz sand, olive-black, fine, well sorted, phosphorite < 1 - 3 %.
G29.0	95.0	Quartz sand, slightly silty, olive, fine, fairly well sorted, phosphorite ~ 2%, grains different shades.
G32.0	105.0	As above, phosphorite < 1 %.
G35.1	115.0	Silty sand, dark olive, very fine to fine, well sorted, phosphorite grains are light and dark, phosphorite 1 - 2 %.
G38.1	125.0	Quartz sand, olive-black, fine, well sorted, glauconite, phosphorite < 1 - 2 %.
G41.0	134.5	Silty quartz sand,olive, very fine to fine, fairly well sorted, light colored phosphorite ~ 2 %.
G41.1	135.0	As above, trace glauconite, phosphorite < 1 - 1 %.
G44.2	145.0	As above, phosphorite < 1 %.
G47.5	156.0	As above, phosphorite ~ 1 %.
G50.6	166.0	As above, dark/light pellets, phosphorite < 1 - 1 %.
G53.6	176.0	Quartz sand, light olive, very fine, well sorted, phosphorite < 1 %.

G56.7	186.0	Quartz sand, speckled with phosphorite, olive-black, very fine, well sorted, phosphorite ~ 1 %.
G60.0	197.0	Quartz sand, olive, fine to medium, poorly sorted, phosphorite pellets varicolored, up to .7 mm, phosphorite 11 %.
G63.4	208.0	Quartz sand, light olive-black, medium, well sorted, trace glauconite, phosphorite ~ 3 %.
G63.6	208.5	Silty quartz sand, light olive, very fine to medium, well sorted, phosphorite 1 - 3 %.
G63.7	209.0	Silty sand, olive, very fine to medium, fairly well sorted, phosphorite 2 - 3 %.
G66.0	216.5	Very silty sand, olive-black, very fine to medium, poorly sorted, varicolored pellets, phosphorite 7 - 10 %.
G66.1	217.0	Very silty quartz sand, light olive-black, fine to medium, well sorted, phosphorite ~ 4 %.
G66.4	218.0	As above, silty sand, dark brown, phosphorite ~ 4 %.
G66.8	219.0	Very silty sand, dark brown, very fine to medium, fairly well sorted, forams, phosphorite ~ 3 %.
G66.9	219.5	Silty quartz sand, dark olive, very fine to medium, fairly well sorted, phosphorite 2 %.
G69.5	228.0	Sand, dark black with pieces of light olive clay, very fine to medium, fairly well sorted, phosphorite ~ 27 %.
G69.6	228.5	Silty sand, olive black, very fine to medium, poorly sorted, varicolored phosphorite grains, phosphorite 3 - 43 %.
G69.8	229.0	Clay, light olive, fine, well sorted, no visible phosphorite, matrix gives test.
G72.7	238.5	Clay, light olive-buff, very fine, well sorted, no visible phosphorite, matrix gives test.
G72.8	239.0	Clay, light olive, very fine, well sorted, no visible phosphorite, matrix gives test.
G73.0	239.5	Clay, dark olive, very fine, well sorted, very few visible phosphorite pellets, matrix gives test.
G75.9	249.0	As above.

G76.0	249.0	As above, light olive.
G76.2	250.0	As above a few larger grains, 0.5 mm.
G78.8	258.5	Sand, silty, light olive black speckles, very fine to coarse, poorly sorted, phosphorite 7 - 8 %, grains to 1 mm varicolored.
G78.9	259.0	Very silty sand, brown, very fine to medium, poorly sorted, multicolored phosphorite 10 - 14 %.
G79.2	260.0	Silty sand, light olive, very fine to medium, not well sorted, phosphorite ~ 5 %.
G82.0	269.0	As above, phosphorite 5 - 8 %.
G82.1	269.0	Very silty sand, dark brown, very fine to medium, poorly sorted, multicolored phosphorite 7 - 8 %, possible dolomite.
G82.3	270.0	As above, very silty, dark olive, possible dolomite, phosphorite 4 -5 %, pellets to 1.5 mm.
G84.9	278.5	As above, light olive green-black, phosphorite 3 - 6 %.
G85.0	279.0	As above, phosphorite grains very light and very dark, few forams, phosphorite 2 - 3 %.
G85.1	279.3	As above, phosphorite ~ 2 %.
G88.1	289.0	Silty clay, dark olive, fine, well sorted, very little visible phosphorite, few forams, matrix gives test.
G88.2	289.3	As above, possible dolomite.
G91.0	298.5	Clay, olive, very fine, well sorted, forams, very little phosphorite, matrix gives test.
G91.2	299.3	Clay, olive-gray, fine, well sorted, no visible phosphorite, matrix gives test, foraminiferal.
G93.6	307.0	Clay, medium olive, very fine, well sorted, foraminiferal, very few phosphorite grains .1-.3 mm.
G93.7	307.5	As above.
G94.0	308.5	As above.
G96.8	317.5	Clay, olive, very fine, well sorted, foraminiferal, very few phosphorite pellets.
G96.9	318.0	As above, no phosphorite, petroleum smell upon acid

		application, matrix gives test.
G97.1	318.5	As above.

Table III-8. Lithologic description for Tacts Borehole H. Other notes as in Table III-1.

USGS Sample ID	Feet	Description
H1.7	5.5	Sand, grayish, poorly sorted, <1% phosphorite, scattered shell fragments
H4.7	15.5	Sand, gray and white, poorly sorted, medium to very coarse, no phosphorites
H7.5	24.5	Pebbles of lithified carbonate, gray-black with pseudo-conchoidal fracture and brownish interstitial matter .5-1.5 cm along with white quartz sand, slightly limey with 2mm ooids on quartz grains; very smooth black grains not phosphorite
H11.1	36.5	Sand, white-gray, poorly sorted, fine to very coarse, <1% phosphorite, shell fragments, various sized ooids on quartz grains
H12.2	40.1	Pebbles and sand, gray and white, poorly sorted, fine to very coarse,<1% phosphorite, shell fragments, various sized carbonate ooids on quartz grains
H13.6	44.5	Sand, carbonate cemented aggregate (probably cemented after sampling), light gray, fairly well sorted, medium grain, cemented aggregate 8 x 10mm, <1% phosphorite, few shell fragments
H15.8	52.0	Clayey sand, light gray, poorly sorted, very fine to coarse ~2% phosphorite, shell fragments throughout
H18.9	62.0	Sandy clayey carbonate, light gray/brown, poorly sorted, fine to coarse, 6-12% phosphorite
H22.0	72.0	Calcareous sand, buff, poorly sorted, very fine to coarse, with minor admixture of quartz; carbonate is altered, milky looking, but benthic organisms are still visible, 6-8% phosphorite pellets. Two types of pellets, brown are smaller in size, gray-black range in size up to 2mm
H25.6	84.0	Calcareous sand,light gray/brown, poorly sorted, very fine to coarse, 6-8% phosphorite
H28.7	94.0	Calcareous sand, buff, very (quartz) sandy, medium, highly foraminiferal (benthic), 2% phosphorite pellets

H31.9	104.5	Calcareous sand, buff-olive, medium coarse with large carbonate grains, including benthic forams, heavily frosted chalky in appearance, large (fine to medium sand sized) phosphorite pellets, 4%
H34.4	113.0	Calcareous sand, buff, fairly well sorted, fine to very fine, <1% phosphorite, shell fragments
H37.8	124.0C	Calcareous sand, medium to coarse (.2-.7mm), with much foram debris plus cemented carbonate ooze in rounded, ooid-like aggregates; sparse phosphorite pellets,<1%
H40.5	133.0C	Calcareous sand, buff, chalky cemented, with 8% phosphorite pellets
H40.7	133.5C	As above, but fine grained, except for shell fragments, <1% phosphorite
H40.9	134.0	Silty clay, light brown, with very fine sand; sediment had pasty texture and clumps of denser material of same color, forams, 5% phosphorites
H43.3	142.0C	Sand, buff-olive, fine with calcareous admixture; 1-2% phosphorite pellets
H43.4	142.5C	Mainly sand with minor clay, light gray/brown, well sorted, fine grained 3-4% phosphorite, several white clay clasts of different shapes and sizes, forams
H43.6	143.0	Sandy carbonate, olive green, fairly well sorted, fine to medium grain, 3-5% phosphorite, forams
H46.3	152.0	Sand, olive, well sorted, fine, 1% phosphorite
H46.5	152.5	Sand dark clay admixture, olive/brown, well sorted, fine grained, dense clumps of clay and sand, 1-2% phosphorite, occasional carbonate shell fragments
H46.6	153.0	Sandy clay, dark brown, fairly well sorted, very fine to fine. 1-2% phosphorites, some shell fragments
H49.4	162.0	Sand, dark-olive, fine to very fine, well sorted with sparse carbonate shell fragments (.2-.4mm) and phosphorite pellets 3-4%
H49.5	162.5C	Sand, dark olive, well sorted, fine to very fine with sparse carbonate(shell) fragments(.2-.4mm) and phosphorite pellets 3-4%
H49.7	163.0	Sandy clay, dark olive/brown, moist, well sorted, fine to very fine, 4-6% phosphorites, sparse forams, shell fragments

H52.1	171.0	Sandy clay, dark olive, well sorted, very fine, 4-6% phosphorite with some carbonate
H52.4	172.0	Sand, dark brown, fine, well sorted, sparse carbonate and phosphorite 2-3%
H55.2	181.0	As above, silty with ~ 5% phosphorites
H55.4	182.0	Sand, dark brown, well sorted, fine grain, sparse carbonate and phosphate 4-5%
H58.2	191.0	Sand, dark brown, 2% dark, well sorted, fine, 2-3% phosphorite pellets
H58.4	191.5C	Silty sandy clay, dark olive, well sorted, fine grain, 2-4% phosphorite, sparse carbonates
H58.5	192.0	As above, 4-5% phosphorites
H58.7	192.5	As above, 2-3% phosphorites
H59.0	193.5	As above, 1% phosphorites
H61.0	200.0C	Sand, dark olive-green, well sorted, fine to very fine, speckled with dark phosphorite pellets of corresponding size (<1%); streaks of dark brown-gray clay, .5-1mm wide
H61.1	200.5C	Sand and clay, dark olive, well sorted, fine to very fine, <1% phosphorite
H61.3	201.0	As above, 1% phosphorite pellets
H66.8	219.0	Sand, light brown, fairly well sorted, fine grained, 1-2% phosphorite of different sizes
H69.8	229.0C	Sand, dark brown, white buff clay clasts, fairly well sorted, fine grained, various sized and shaped phosphorite pellets 2-4%
H70.0	229.5C	Sand, dark brown-olive, micaceous looking in part, with buff clay clasts, 5-10 mm, and variably shaped and sized phosphorite pellets, 2-3%, clay clasts have sharp edged irregular boundaries, clay has slightly phosphatic reaction
H70.4	231.0C	Sandy clay, light olive, fine grained, large percentage carbonate microfossils, no phosphorite pellets, however, sample produces a positive P test
H70.6	231.5C	As above
H72.9	239.0C	As above, with very small phosphorite grains <1%

H73.0	239.5C	As above, <1% phosphorite, many of the microfossils contained within their tests micropellets of phosphorite. Some of the microfossils had chambers that were full of the pellets while others had very few pellets
H75.9	249.0	Clay, light olive green, containing mainly microfossils, no apparent phosphorite, sample gives a positive P test, emits a petroleum smell when acid is added
H78.0	259.0C	Clay with very little fine grained sand, olive green, sample is full of microfossils similar to those stated above, sample gives positive P test, although little phosphorite may be seen
H82.0	269.0C	As above
H82.1	269.5	As above
H85.0	279.0C	As above
H85.2	279.5C	As above
H88.1	289.0C	As above, with some planktonic forams included.
H88.2	289.5	As above
H94.2	309.0C	As above, contains some glauconite pellets throughout
H94.2	309.0	As above, contains few rather large phosphorite pellets
H97.2	319.0	As above

Table III-9. Lithologic description for AMCOR Hole 6002. The data cited here are taken from "Visual Core Descriptions" of the Atlantic Margin Coring Project, 1976, from "Smear Slide Data" and from later laboratory measurements (Poppe, 1981). Percentage numbers before the phase refer to visual or x-ray diffractions estimation. Percentages after the phase refer to chemical determinations. The depths are nominal, taken mainly from Appendix I in Poppe (1981). The decimal numbers are reported for consistency and to indicate approximate distance between samples only.

Core	Sec.	Depth Meters	Depth Feet	Description
1	1	.1	.3	Sand, dark grayish brown, quartz, shell fragments, trace glauconite, possible trace apatite; $CaCO_3$ 9.1%, 7.3%, P_2O_5 .13%, .18%
2	1	8.3	27.2	Silty to limy clay, olive gray, sandy, pebbly, trace dolomite, possible trace apatite, abundant diatoms, $CaCO_3$ 18.8%, P_2O_5 .99%
3	1	17.8	58.4	Sand, olive gray, phosphate and shell fragments, P_2O_5 1.85%
3	2	19.5	64.0	Clayey to sandy silt, 28% dolomite, 1% pyrite, 1% apatite
3	3	20.6	67.6	Silty clay, olive gray
		21.2	69.5	Clayey sand, olive gray, with shell fragments
3	4	22.2	72.8	Same as above
3	5	23.	78.4	Clayey sand, olive, shell fragments
		24.7	81.0	Clay, olive
		24.	81.3	Clayey sand, olive, shell fragments
3	6	26.1	85.6	Clayey sand,olive, shell fragments, coarse, massive bedded, well mixed
		26.4	86.6	Silty to clayey sand, olive, fine, apatite pellets?
		27.2	89.2	As above, bioturbated?, not well mixed
4	1	27.5	90.2	Silty clay, olive, P_2O_5 2.34%
4	2	28.2	92.5	Clayey silt, minor sand, olive, 10% dolomite, 1% pyrite, 15% diatoms, sponge spicules

4	3	30.5	100.0	Silty clay, olive
4	4	31.5	103.3	Silty clay, olive
4	5	32.	107.3	As above
4	6	35.5	116.4	Silty clay, olive, 30% diatoms, sponge spicules, and radiolarians; dolomite 22.2%, P_2O_5 1.50%
5	1	36.1	118.4	Silty clay, olive, P_2O_5 .81%
		36.1	118.4	Clay,olive
6	1	41.2	135.1	Silty clay, olive, P_2O_5 1.57%, 7.04%, 1.57%
6	2	45.6	149.6	Sandy to clayey silt, trace pyrite, glauconite, 14% dolomite
7	1	50.6	166.0	Silty clay, olive
7	2	51.3	168.3	Silty clay, olive, no apatite, 26% dolomite, 2% pyrite$CaCO_3$ 18.4%, P_2O_5 23.35%
8	1	59.4	194.8	Clay, olive, P_2O_5 .99%
8	2	60.3	197.8	Silty clay, olive
8	3	61.8	202.7	Silty clay, olive, nannofossils, trace pyrite, forams, dolomite, $CaCO_3$ 18.3%
9	1	69.3	227.3	Silty clay, olive
9	2	70.7	231.9	Silty clay, olive, P_2O_5 1.05%
9	3	72.2	236.8	Silty clay, olive
9	4	73.7	241.7	Silty clay, olive
9	5	75.2	246.7	Sample missing
9	6	76.7	251.6	Silty dolomitic clay, olive, trace pyrite, forams, nannnofossils, $CaCO_3$ 36.0%, P_2O_5 3.37%
10	1	79.0	259.1	Silty clay, olive
10	2	79.2	259.8	Clayey silt, olive, trace pyrite, dolomite, 10% forams, calc. nannos, $CaCO_3$ 36.8%, 38.4%, P_2O_5 2.15%
11	1	86.6	284.0	Clay, olive, P_2O_5 5.06%

11	2	88.3	289.6	Silty clay, minor sand, olive
12	1	97.9	321.1	Calcilutite, olive gray, P_2O_5 .38%
12	2	98.2	322.1	Calcilutite, olive gray
12	3	99.7	327.0	Calcilutite, olive gray
13	1	107.4	352.3	Silty carbonate, olive gray, P_2O_5 .25%
14	1	117.1	384.1	Clayey carbonate, lt olive gray
14	2			Contained only water
14	3			As above
14	4			As above
14	5	123.7	405.7	Silty clay, nannofossil rich, light olive gray, trace glauconite, pyrite, 15% zeolite
14	6	124.0	406.7	Silty clay, carbonate rich, light olive gray, trace glauconite, pyrite, dolomite, diatoms, possible trace apatite
15	1	126.6	415.2	Carbonate, light olive gray, P_2O_5 .31
15	2	128.	419.8	Clayey to silty carbonate, light olive gray, trace pyrite, 5% zeolite, $CaCO_3$ 70.7%, 72.7%
15	3	129.0	423.1	Carbonate, light olive gray
15	4	129.8	425.7	Silty carbonate, light olive gray,
16	1	136.0	446.1	Silty carbonate, light olive gray, large mollusk fragments scattered throughout
16	2	137.1	449.7	Silty carbonate,light olive gray, slight phosphate, limestone, light olive gray, some shells, phosphate P_2O_5 .60%, .68%.
		137.5	451.0	Clayey carbonate sand, olive gray, phosphatic, shells
16	3	139.3	456.9	Limestone, light olive gray, fossiliferous
		139.4	457.2	Silty carbonate, light olive gray P_2O_5 .26%

17	1	146.1	479.2	Silty carbonate, light olive gray
17	2	147.2	482.8	Chalk, light olive gray, 5% zeolite, $CaCO_3$ 86.7%, 87.0% light carbonate is probably recrystallized nannofossils
17	3	149.0	488.7	Silty clayey carbonate sand,light olive gray, scattered phosphatic grains, scattered large mollusk fragments, P_2O_5 .59%, 1.83%
17	4	153.5	503.5	Sandy carbonate, light olive gray, phosphatic, large mollusk fragments scattered throughout
18	cc	164.3	538.9	Core catcher only, fine white sand and shells
19	1	164.4	539.2	Limestone, light olive gray, fine grained, P_2O_5 .19%
19	2	165.4	542.5	Silty zeolitic carbonate sand, light gray, trace pyrite, $CaCO_3$ 82.7%, 82.1%
19	3	170.7	559.9	Limestone, light gray, megafossils, phosphate?
19	4	172.	564.8	Limestone, clay, light gray, fossils present
20	1	174.4	572.0	Limestone, light olive gray
20	2	175.9	577.0	Calcareous limestone, light olive gray
20	3	177.0	580.6	Limestone, light olive gray, P_2O_5 .15%
20	4	180.2	591.1	Clayey limestone, light gray
20	5	181.7	596.0	Clayey silty limetone, light gray
21	cc	192.6	631.7	Core catcher only, limestone
22	1	192.9	632.7	Slightly silty carbonate sand, light gray, trace dolomite, $CaCO_3$ 92.7%, P_2O_5 .15%, .14%
22	cc	197.0	646.2	Limestone, core catcher; no other information
23	1	202.6	664.5	Clayey limestone, light gray, fossils present
23	2	203.8	668.5	Silty carbonate sand, light gray, trace

				dolomite, glauconite, $CaCO_3$ 88.8%, P_2O_5 .16%
23	3	206.0	675.7	Clayey limestone, light gray
24	1	211.7	694.4	Silty carbonte sand, light gray, trace dolomite, zeolite, $CaCO_3$ 90.9%, P_2O_5 .17%, .25%
		212.7	697.7	Limestone, fossiliferous, light gray, scattered phosphate grains
25	cc	221.4	726.2	Core catcher only, hard white sandy limestone
26	cc	235.2	771.5	Core catcher only, recovered, limestone
27	cc	240.1	787.5	Core catcher only, hard white sandy limestone, P_2O_5 .14%
28	1	249.9	819.7	Silty carbonate sand, light olive gray, trace glauconite, $CaCO_3$ 86.4%
29	cc	263.8	865.3	Core catcher only, fossiliferous, clayey sand
30	cc	273.3	896.4	Core catcher only, hard limestone and fine sand
31	cc	282.7	927.3	Core catcher only, hard limestone fragments and fine sand
32	cc	287.6	943.3	Core catcher only, hard fine grains of white limestone
33	1	297.9	977.1	Zeolitic carbonate silt, light gray, $CaCO_3$ 54.7%, P_2O_5 .11%, .09%

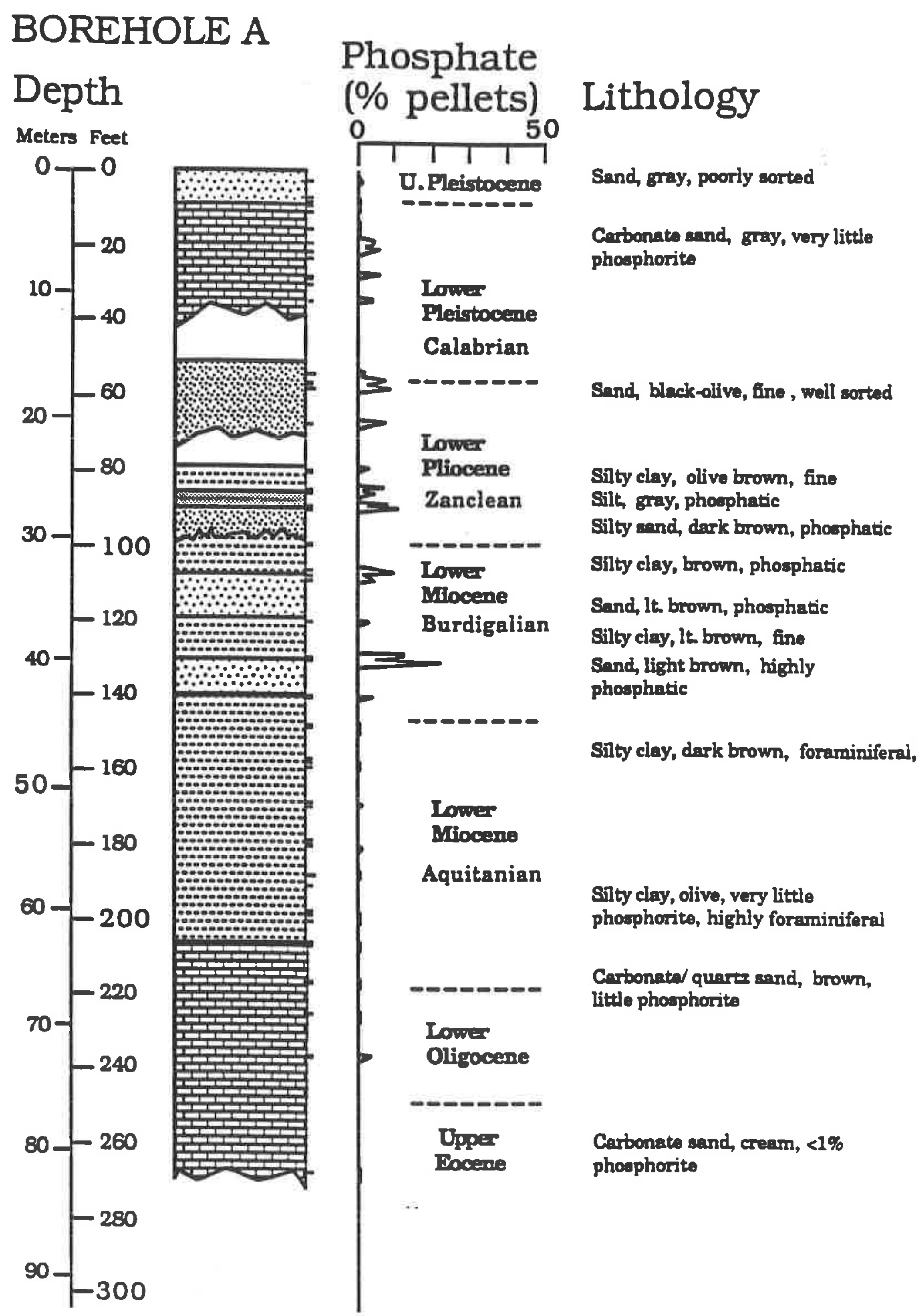


Fig. III-1. Core log, Borehole A

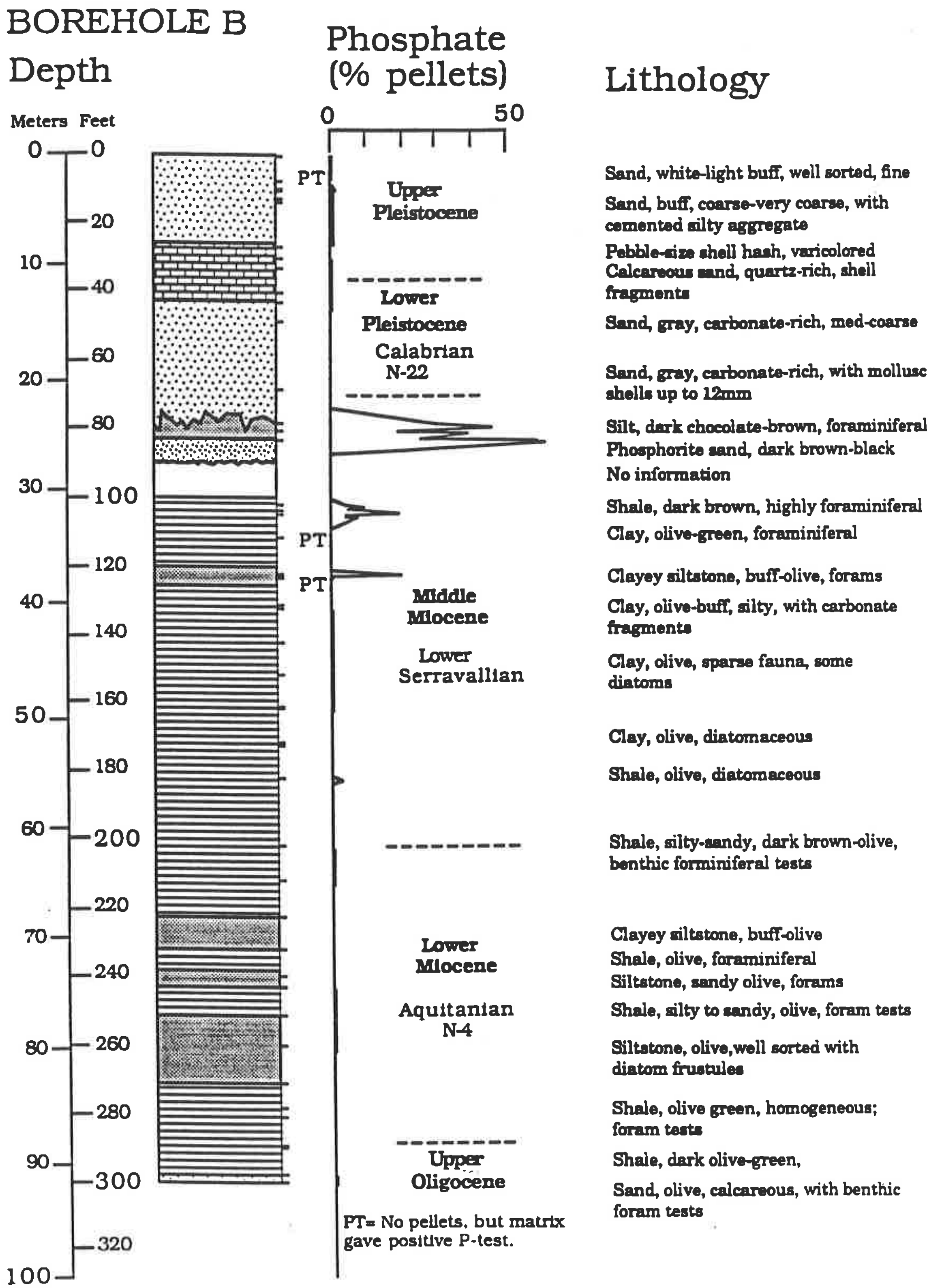


Fig. III-2. Core log, Borehole B

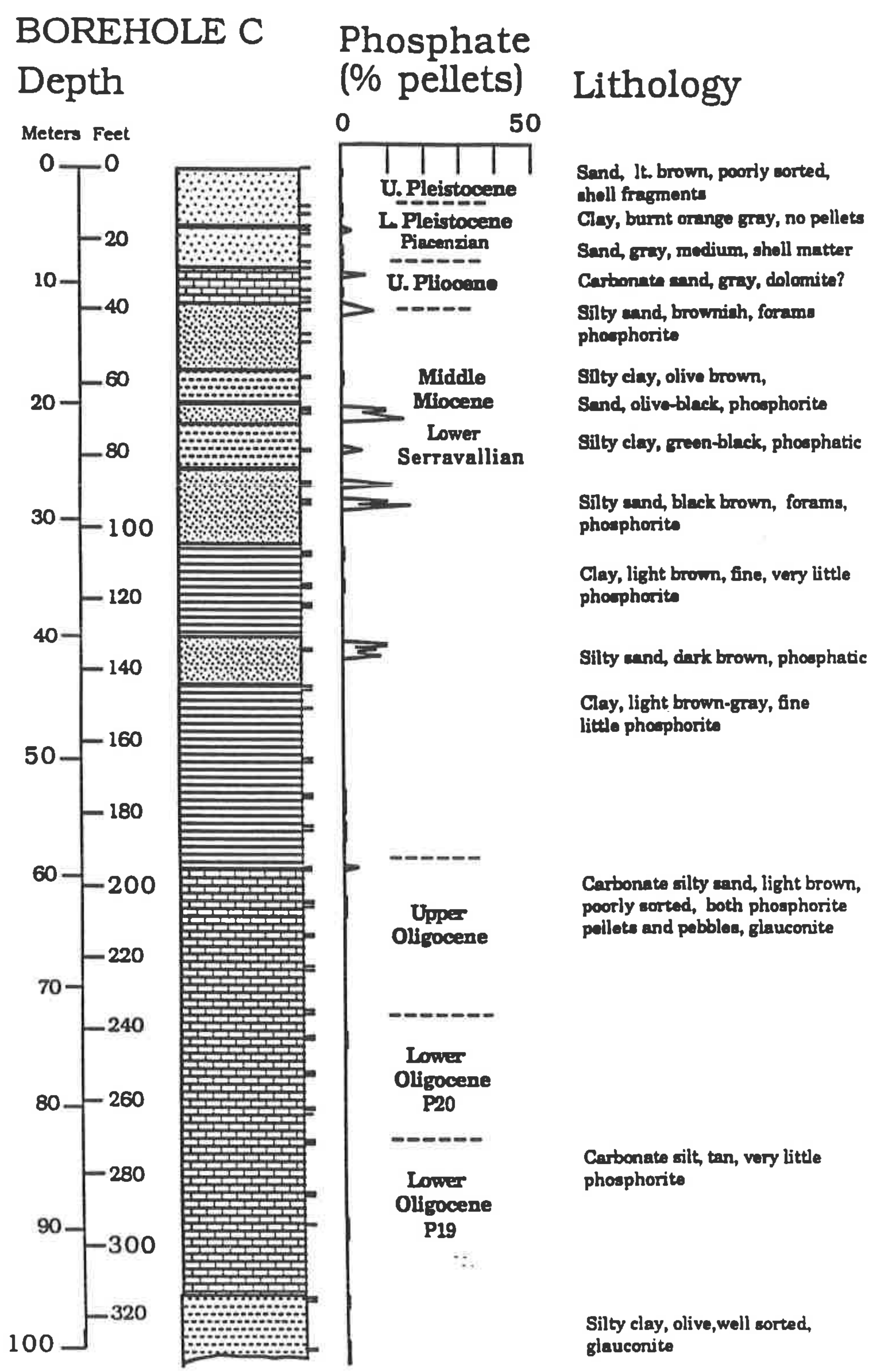


Fig. III-3. Core log, Borehole C

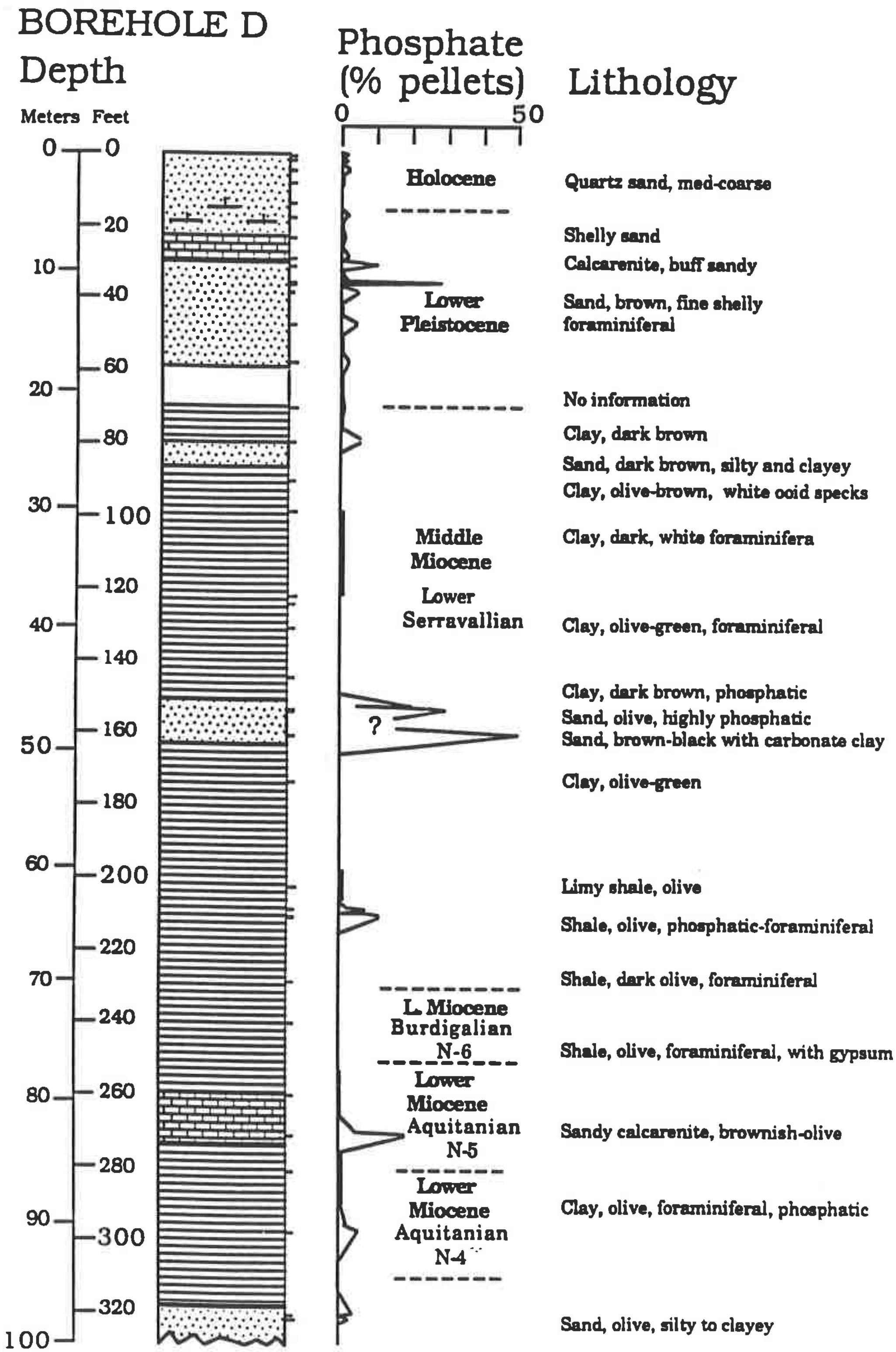


Fig. III-4. Core log, Borehole D

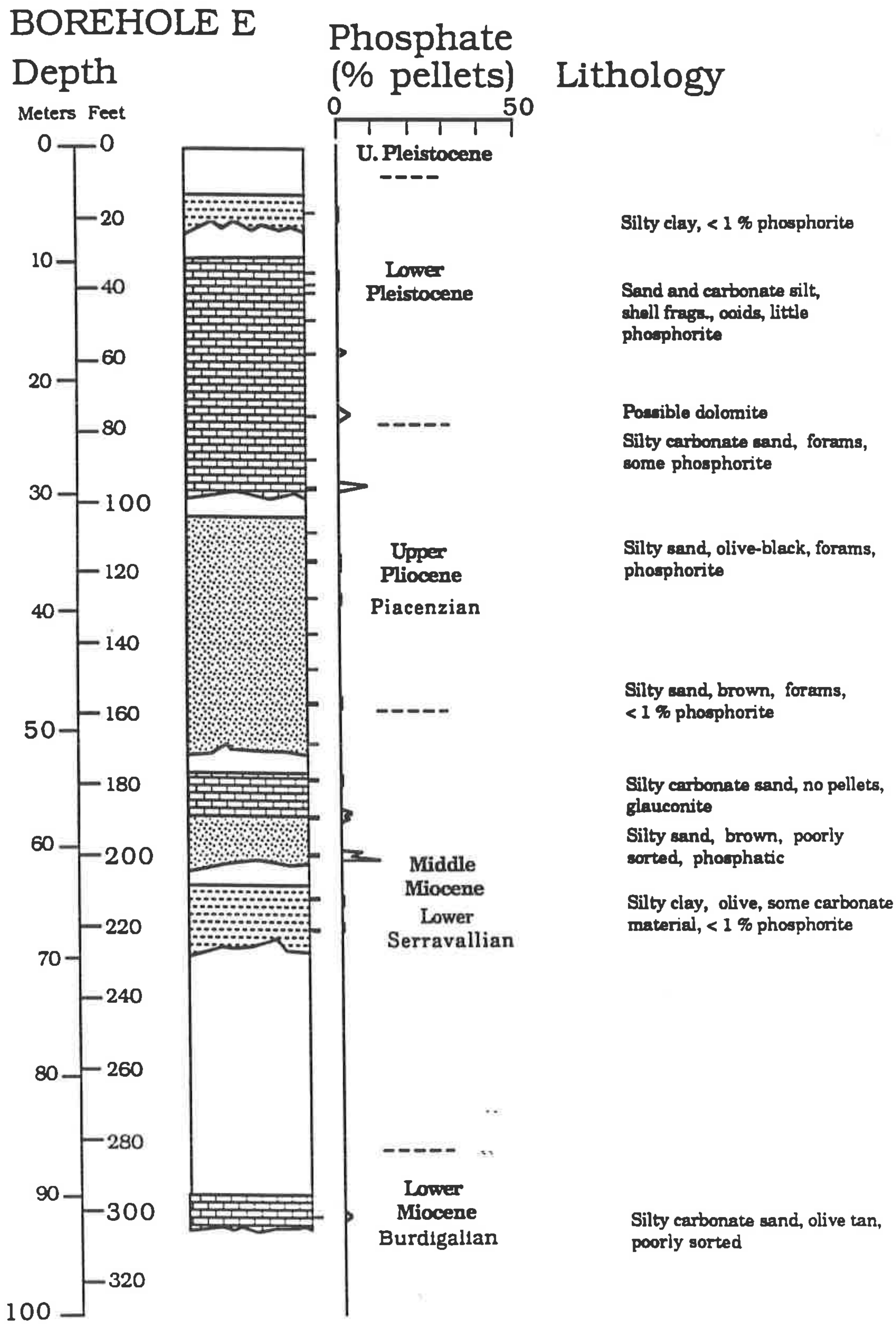


Fig. III-5. Core log, Borehole E

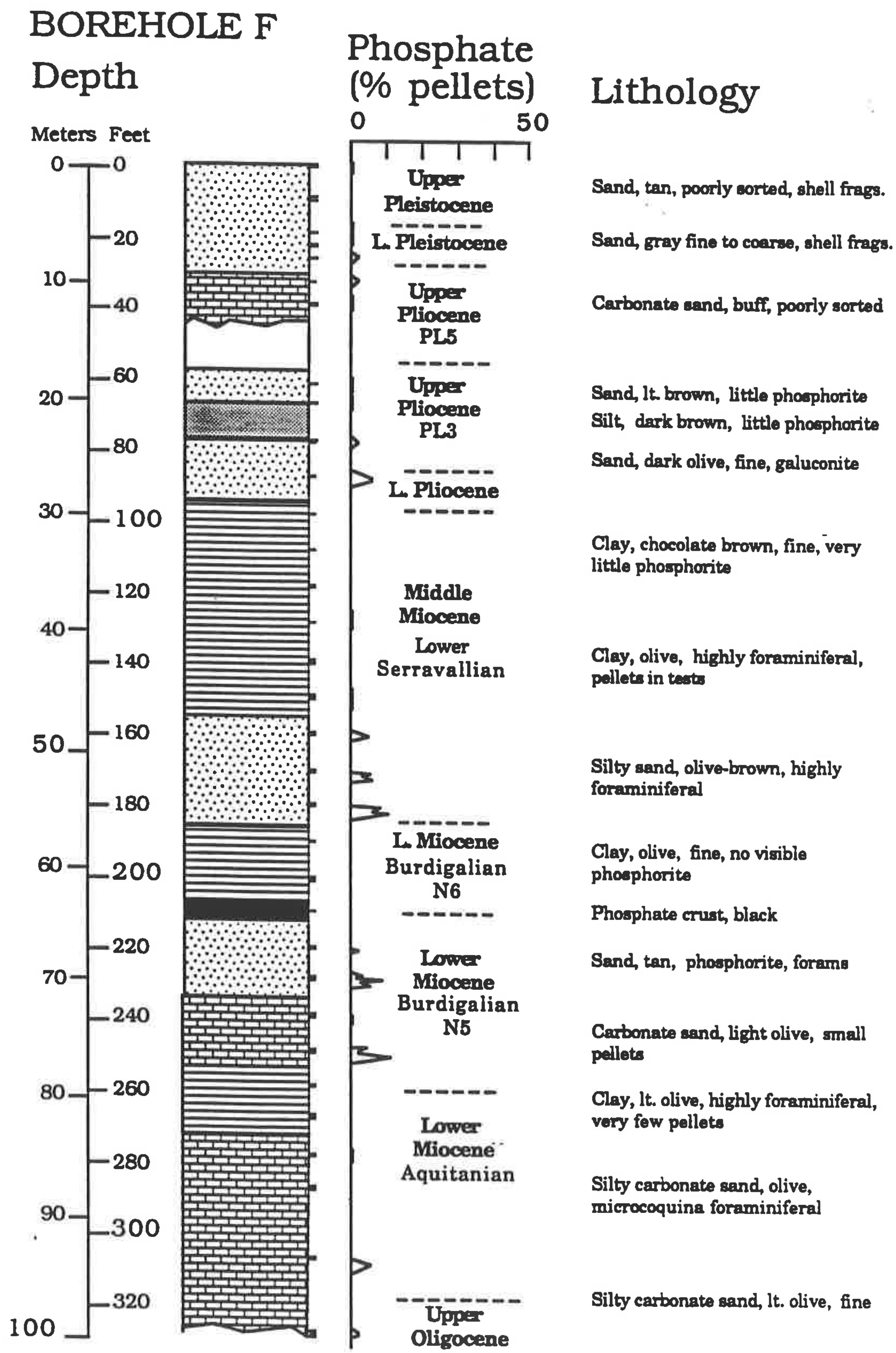


Fig. III-6. Core log, Borehole F

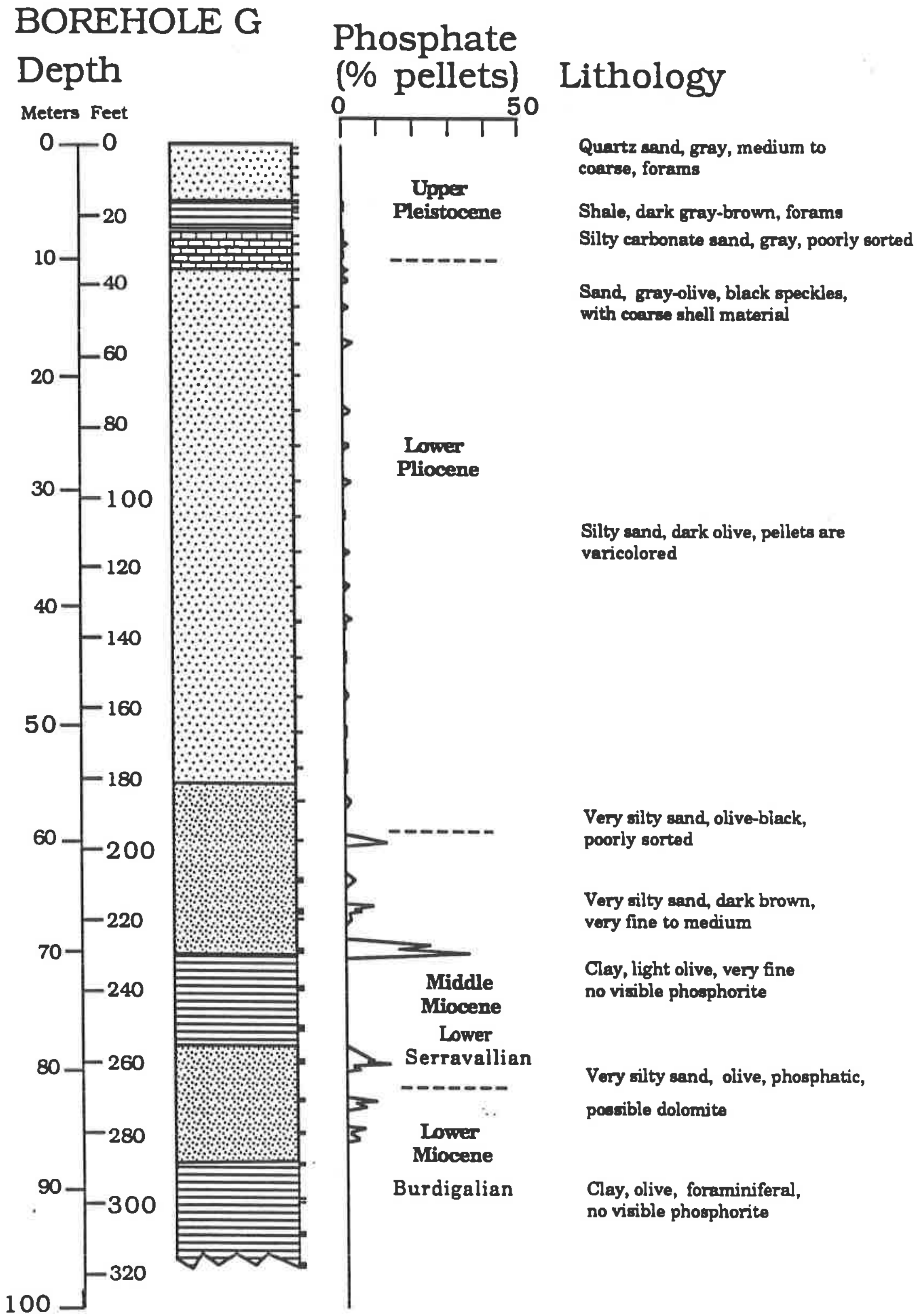


Fig. III-7. Core log, Borehole G

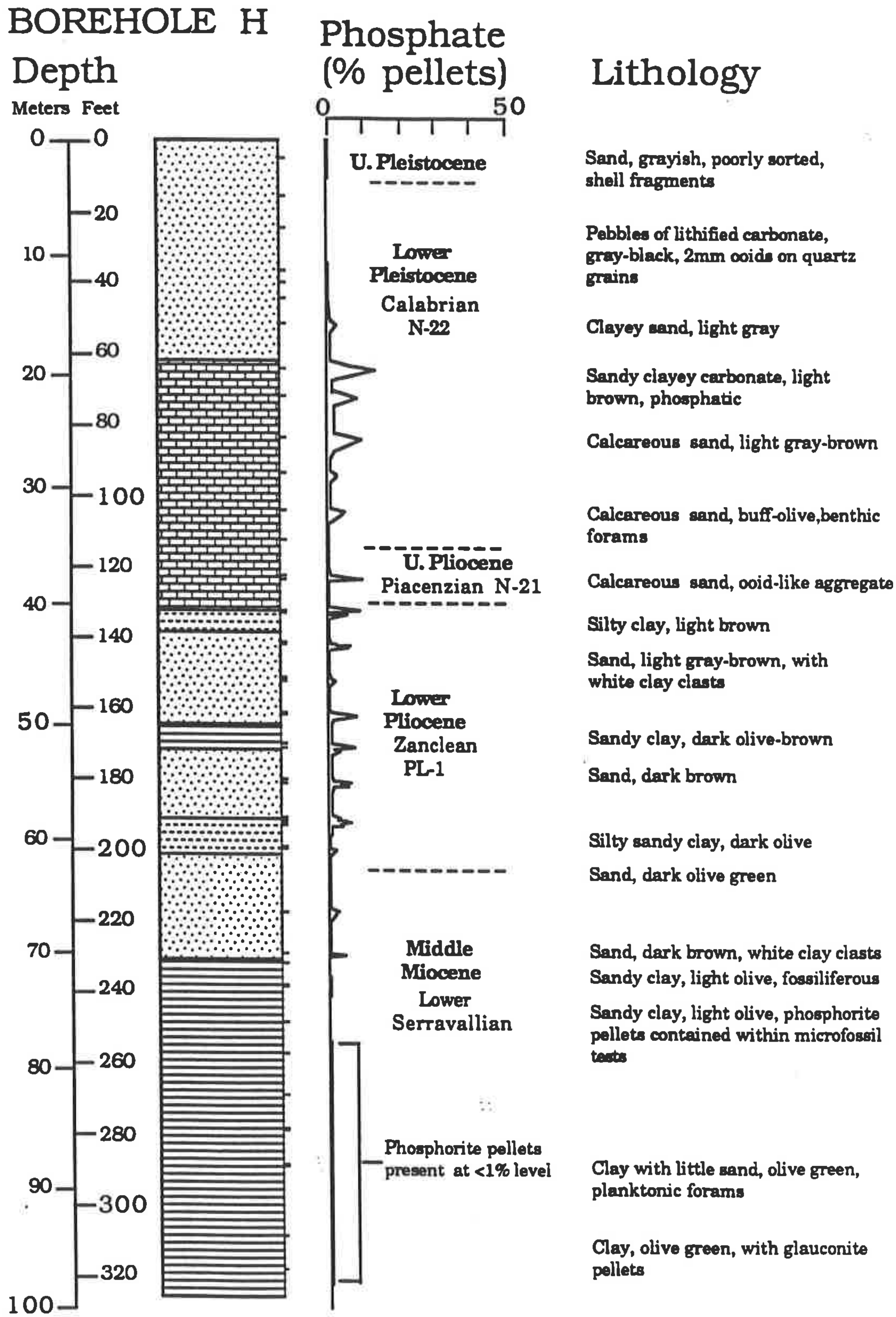


Fig. III-8. Core log, Borehole H

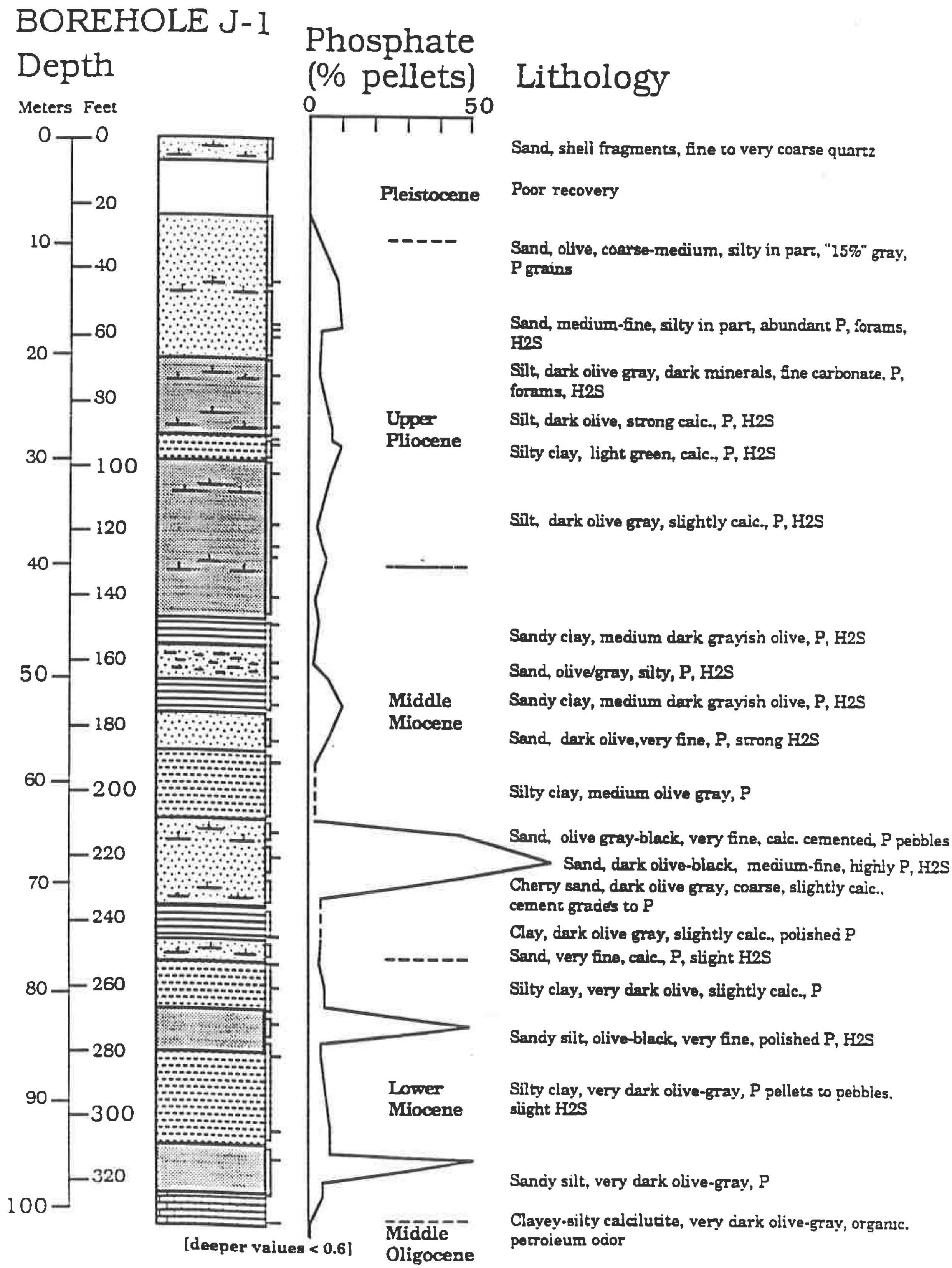


Fig. III-9. Core log, Borehole J-1

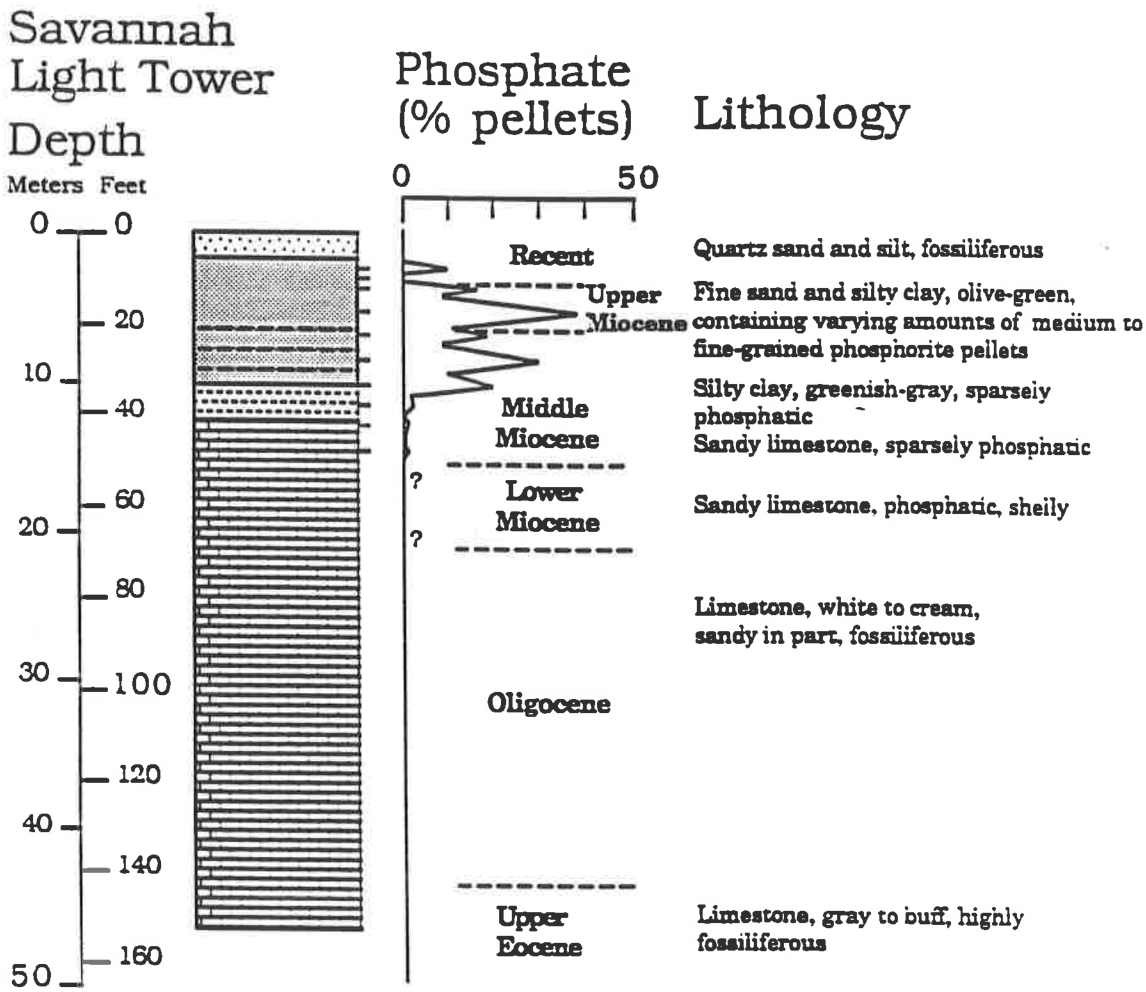


Fig. III-10. Savannah Light Tower

Fig. III-11. Core log, AMCOR Hole 6002

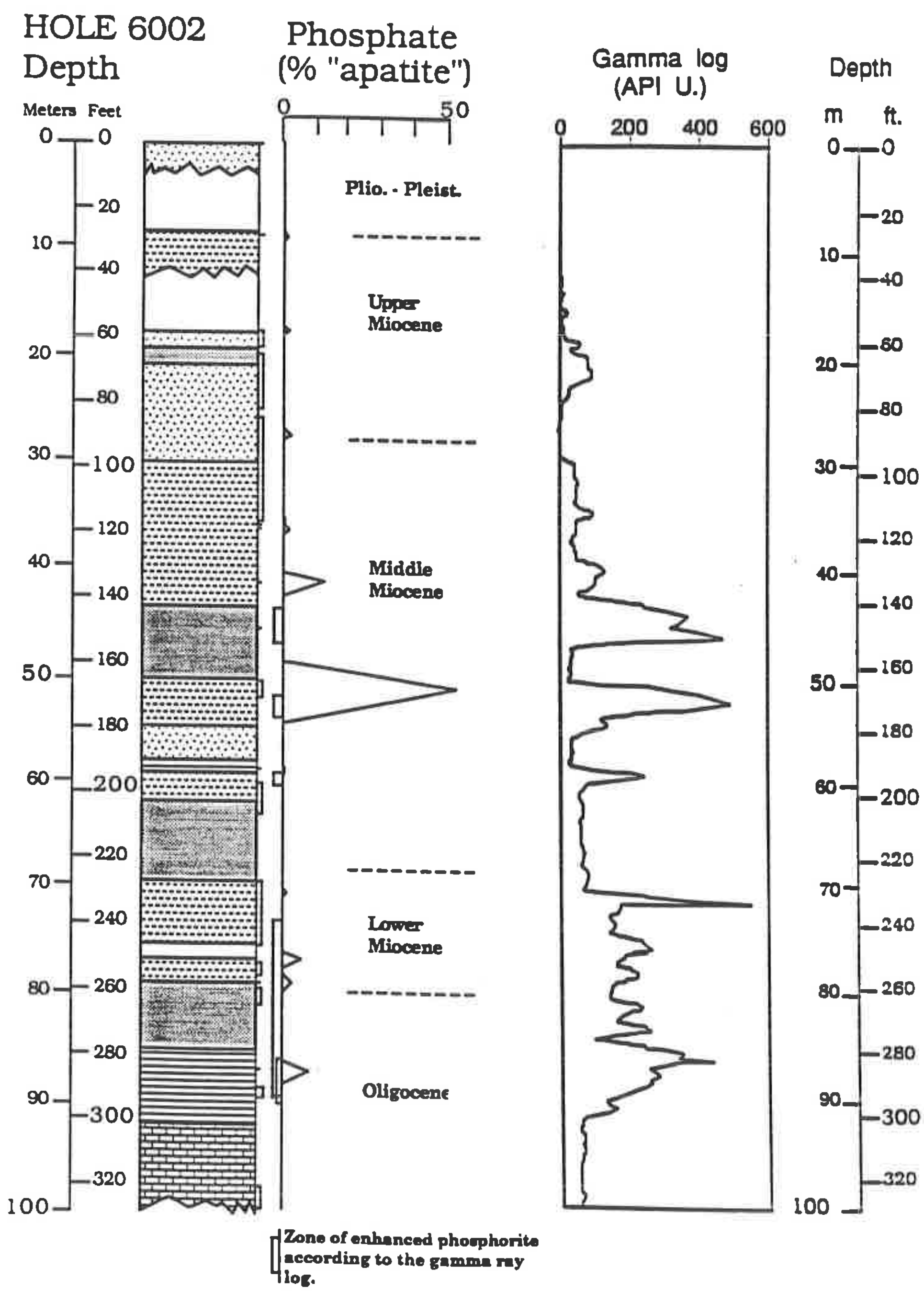


Fig. III-12. West to East stratigraphic profile

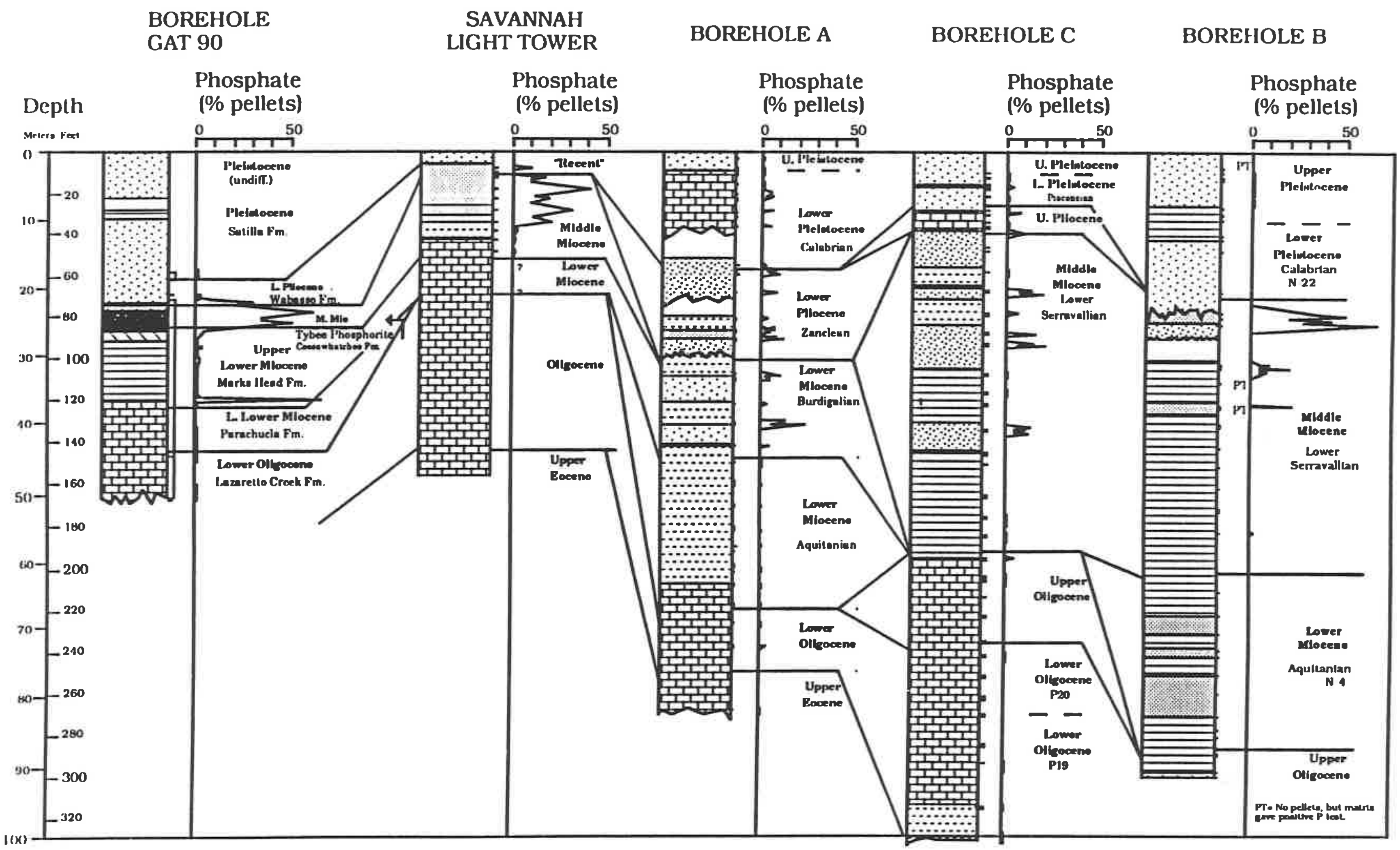


Fig. III-13. North to South stratigraphic profile

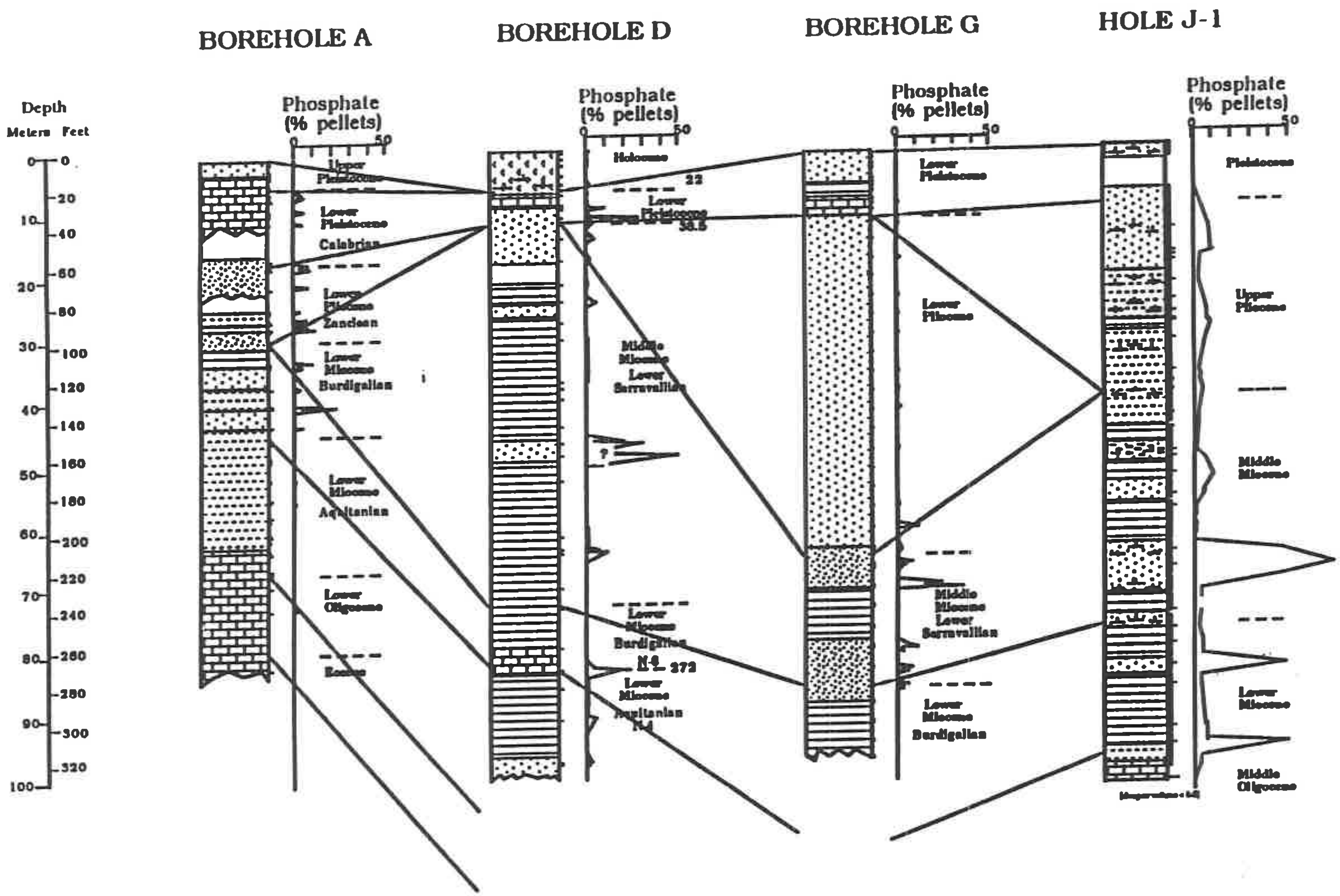


Fig. III-14. South Atlantic correlation chart, from Popenoe (198x)

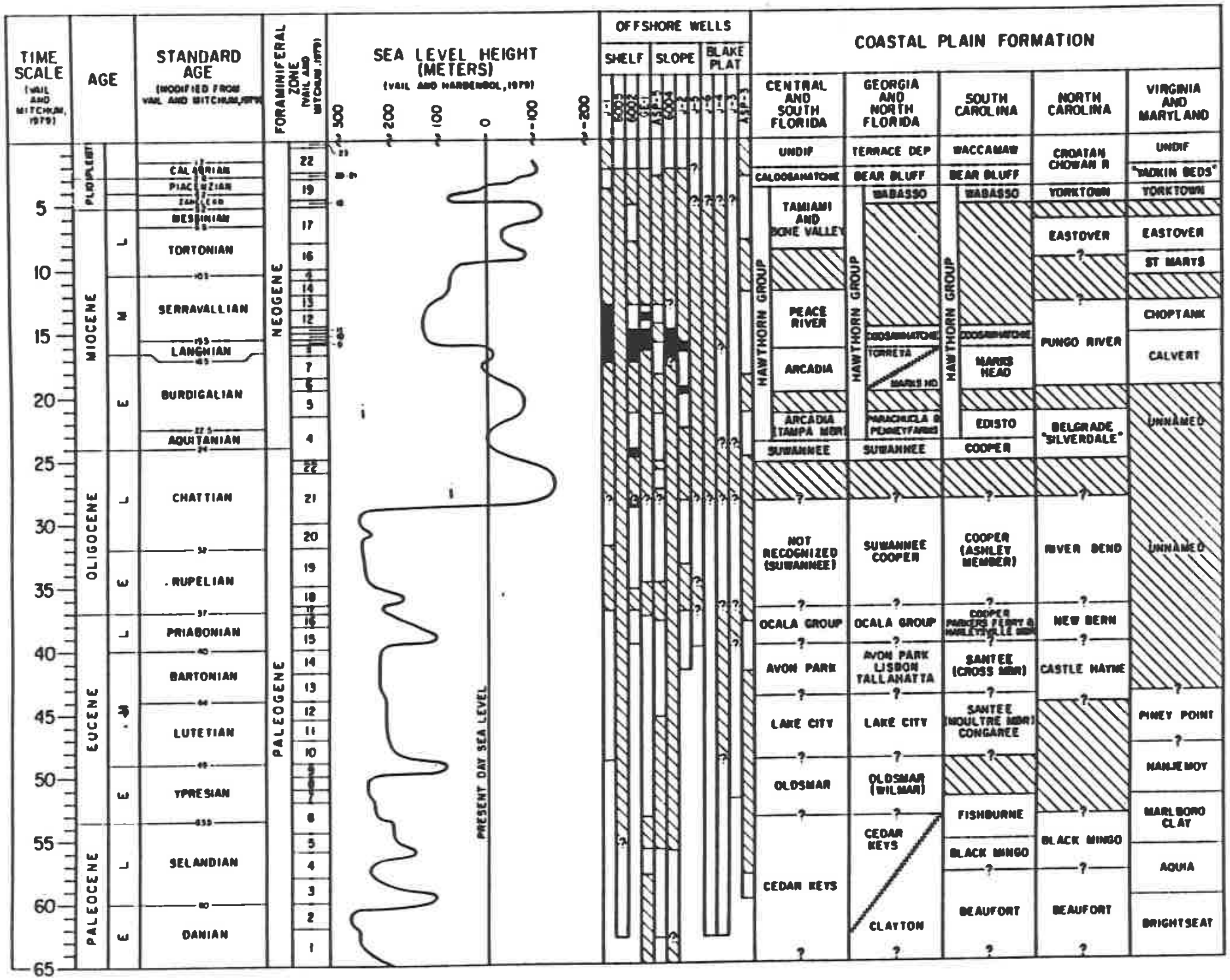
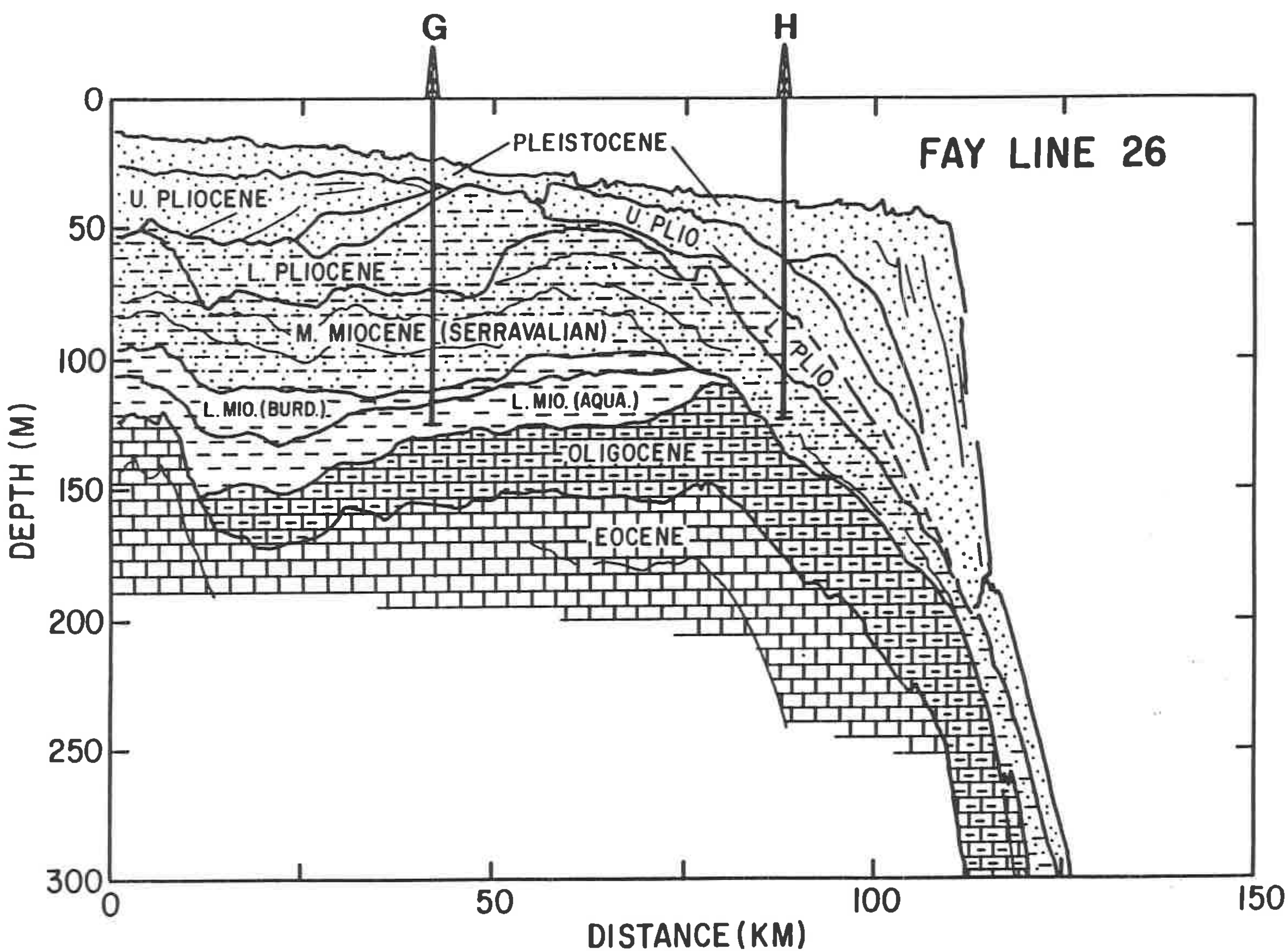


Fig. III-15. W to E section across shelf and slope.
(Fay Line 26). Mofified from data in Popenoe (1991).



IV Texture, origin, and significance of phosphorite pellets

By F.T. Manheim and J.R. Herring

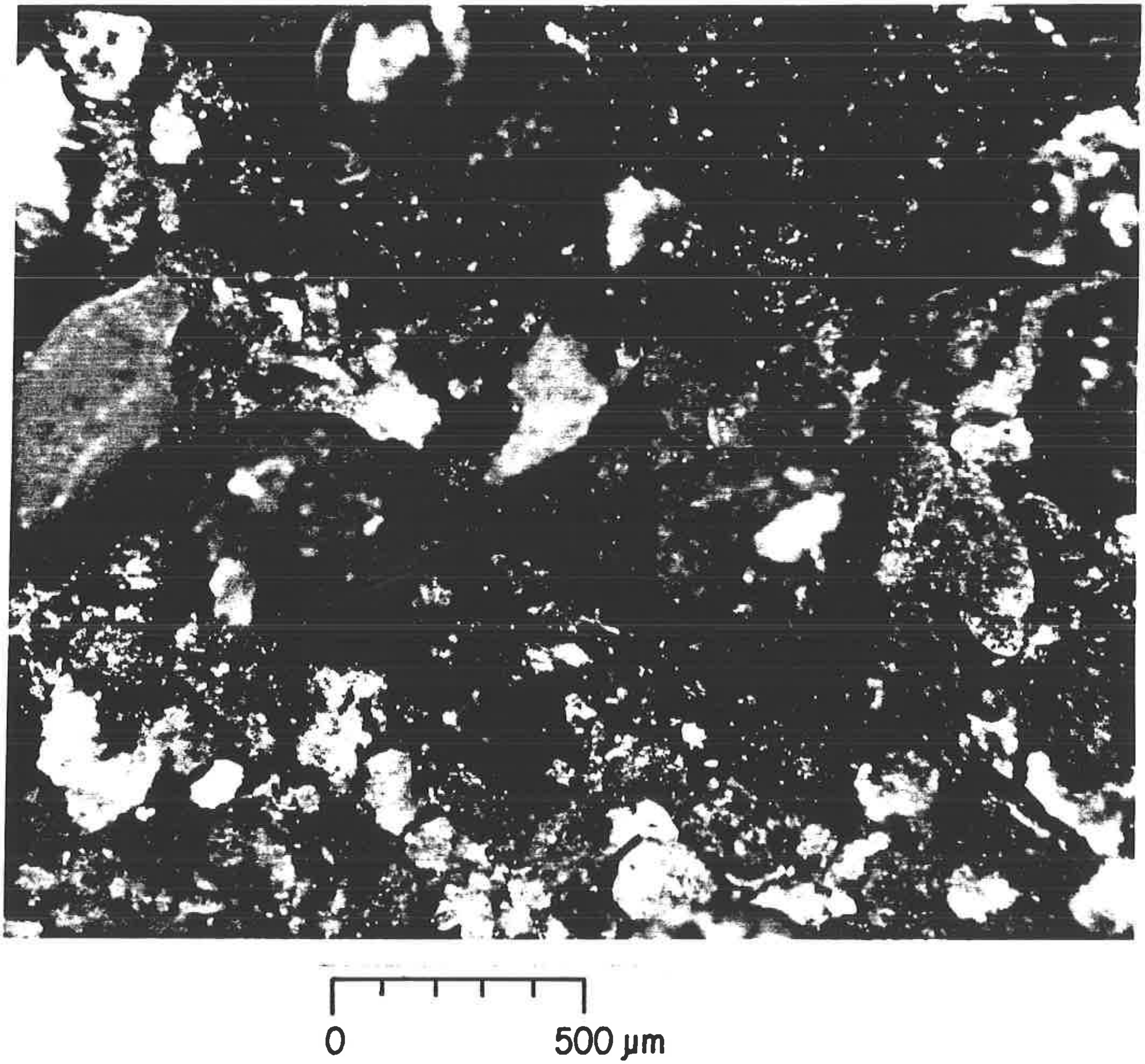
Neogene to Recent phosphorites occur along the southeastern U.S. margin in many forms: cryptograined material (<.1uM) and micrograins (<.0625 mm), called "microsphorite", "fecal pellets", "pellets", oolites, "intraclasts" or fragments of penecontemporaneous phosphorite sediments reworked from adjacent sea floor, phosphatized skeletal debris such as fish vertebrae and teeth, molds of organisms, pebbles and larger cemented aggregates (Riggs, 1979).

Many of the above types are best known from the land deposits in Florida. The Georgia shelf deposits fall into the category of sediments "deposited down the depositional slope" (Riggs, 1979), in which phosphorite is dominated to 80-90% by fine pellets. This description fits the Georgia shelf deposits well (Fig. IV-1). However, the origin of the pellets, and whether they represent insitu or transported forms remains controversial. The distinction is a critical one, both for scientific and practical reasons (Weaver and Beck, 1977), but "little has been done to determine specific criteria that are useful for its recognition" (Snyder et al, 1982).

Many authors have referred phosphorite pellets as forming from coprolites or fecal pellets (Cayeux, 1939; Visse, 1974; Riggs, 1979;, Porter and Robbins, 1981; and Lamboy, 1982). This chapter offers preliminary evidence that many if not most pellets in the shelf off Georgia were originally formed inside foraminiferal tests, both benthic and planktonic. We provide two criteria for recognizing primary phosphatic (in situ) pellets of this type.

Simple but effective optical methods for determining the proportion and size of phosphorite pellets and other sediment parameters have been important in the TACTS work. Because the variants appear not to have been specifically referred to in literature known to us, the techniques are briefly described here.

Figure IV-1. Microphotograph of typical phosphorite rich sediment. Sample is from 25 m depth in site B (near unconformity at top of Middle Miocene). Darker grains are phosphorite. White to gray samples are mainly carbonate with some clay. Volumetric pellet estimate exceeds 60 percent.



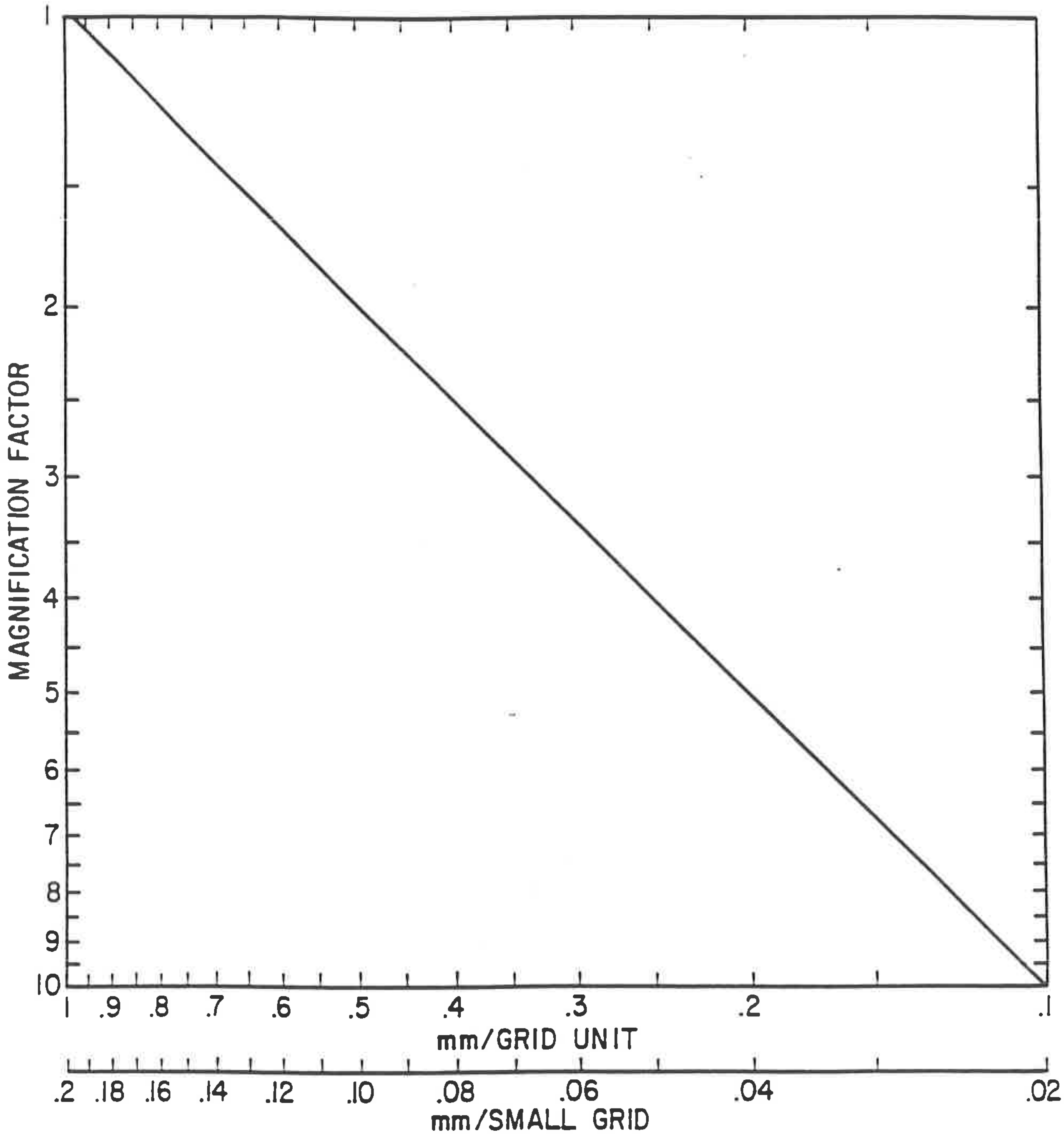
Methods

Two binocular microscopic analysis systems were employed to estimate the proportion of phosphorite pellets in the TACTS cores. The first method (applied by JRH) involved preparation of a series of comparator standards having known concentrations of pellets. The known standards are prepared by first sieving pellets from sediments selected to permit near-complete separation by this method. They were then diluted with non-phosphatic sediments to achieve standard ranges from 3 to 50% carbonate fluorapatite (CFA) by weight. In addition, standard sieving techniques were employed to separate specific fractions for chemical or other analysis.

The second method (applied by FTM) shares with method 1) the advantage that measurements could be performed during the binocular microscopic analysis of general sediment character. It was conducted on wet (natural) sediment using a microscope with a calibrated zoom lens and a 100-cell ocular grid. For photographic purposes the central tube of the microscope was also fitted with a (different) grid. The ocular grid was calibrated with a stage micrometer with .01, .1 and 1mm rulings (Fig. IV-2). The method yielded volumetric estimates of pellet concentrations, with weight/weight conversions possible by computation. Because these measurements were used to gain several key types of information the technique is described in more detail.

The sediment is first dispersed with water containing .01% of a wetting agent (e.g. Kodak Photoflo solution). A section of the smear slide is chosen such that the bottom of the slide is evenly and representatively covered with grains. The tendency for grain separation around the edges of the preparation may be utilized to examine special phases, but is avoided for grain counts. For semi-quantitative estimation of well-sorted phosphorite grain percentages the magnification is adjusted until the approximate median of pellet populations matches the cells of the grid. Then a quick estimate of volumetric grain percentage is given by counting the number of apatite pellets within the 100-cell grid, corrected by a factor discussed below. The size range of the principal distribution of grains (e.g. corresponding roughly to 20-80 percentiles) is measured by comparison with the calibrated ocular grid.

Fig. IV-2. Calibration graph for cell size vs. magnification factor inscribed on the zoom knob of the microscope. The specific factor refers to a 10-power ocular.



Additional 100-cell counts are made as needed to satisfy the observer that a) a number of counts adequate for the purposes is obtained, and b) sufficient grains have been counted to reach the desired detection limit. If one wishes to extend the mesurement range to low concentrations, more 100-cell fields are measured. For example, to detect .2% apatite pellets, it would be necessary to inspect more than 5 100-cell fields.

For more precise volumetric estimates and to get detailed distributions of grain sizes the dimensions of all pellets in one or more 100-cells views were estimated with the calibrated grid. A mean diameter was estimated by the practised eye as D = (length+width+thickness)/3, or
D= 4/π sqrt[A^*] where A* is the area fraction of the grain silhouette with respect to a square cell.

Another analytical problem to be resolved is the role of shape/volume relationships and counting conventions. For well-sorted grains one can count the number of grains in a 100-cell grid, and apply a factor to get volume percent. The volume of counted grains is compared with the volume of 100 cubic cells. If no overlapping grains occurred a volume correction of 1.89 would be needed to correspond to the volume of a cube compared to that of an inscribed sphere. Because most grains approximate a somewhat ellipsoidal shape we used a factor of 1.7 to divide the number of grains where only grain counts were taken. For poorly sorted grains and to permit size frequency measurements for phosphorite pellets individual grain measurements were made. From these tables of pellet size and derived parameters were prepared.

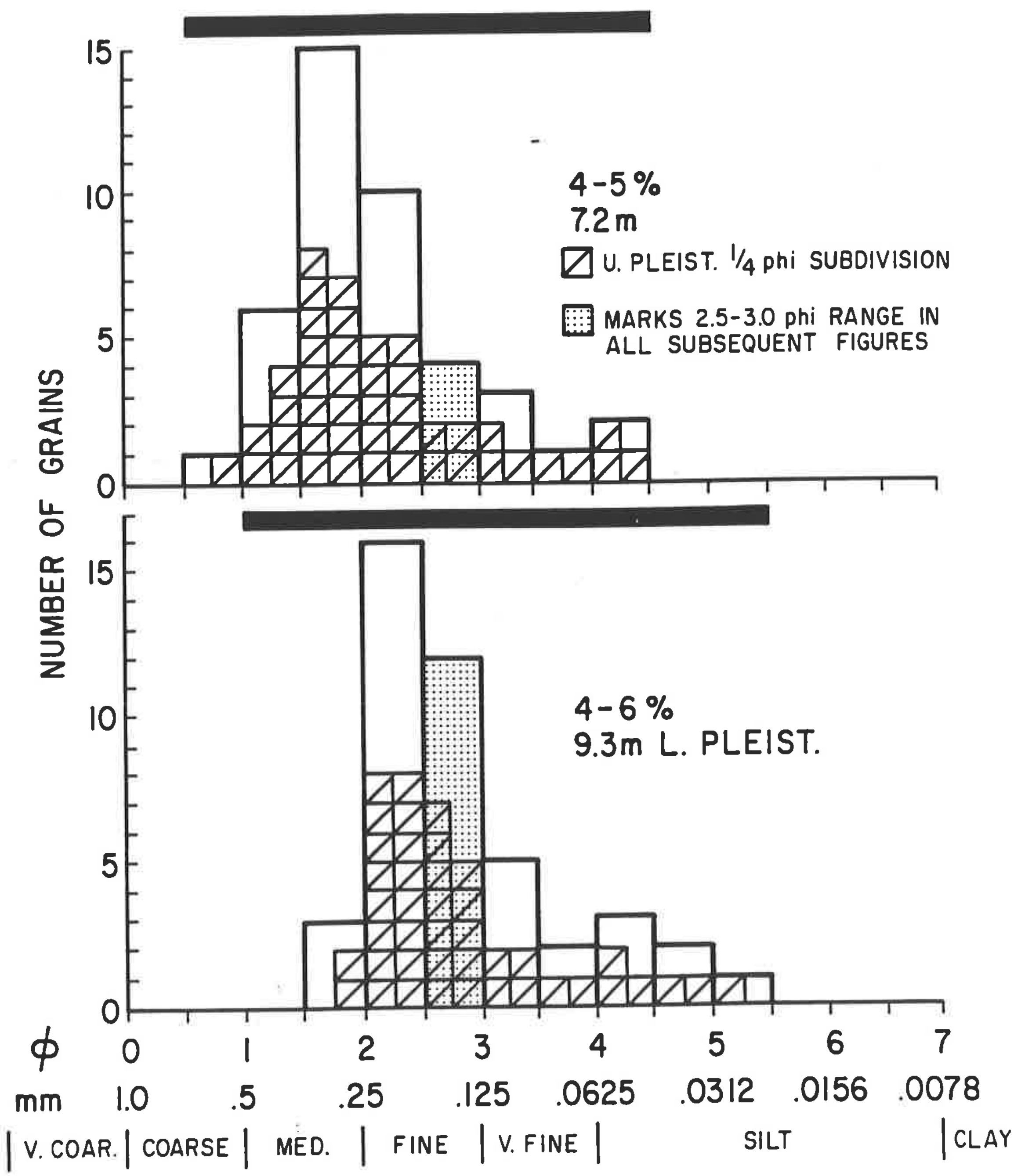
A sample of the spreadsheet describing the textural data obtained from quantitative pellet analysis is given in Table IV-1. Explanation of the units listed and computations follows. The remainder of pellet data are in Appendix 1.

Table IV-1. Volumetric pellet data for TACTS Borehole A. Abbreviations include:

MGU - mean grid units (100-cell grid)
MF - magnification factor (from zoom knob of microscope and calibr. chart)
TGD - true grain diameter - MGU x MF; TGD/2 - radius in mm
EV - equivalent grain volume - $4/3\ \pi r^3$ in mm^3
V (%) - volume percent of CFAP grains per volume of 100 grid units (cubes).
M TGD - mean TGD - sum TGD for sample divided by number of grains
SD - standard deviation (small population)
CV - coefficient of variation.

8	Sample #	Grain No.	MGU	D	R	V	T.V.	AVV		MF	TGD	M TGD	SD	CV
9														
10	A1.1	1	1.1	1.1	0.55	0.69	2.06	1.34		0.30	0.33	0.236	0.125	0.53
11		2	0.9	0.9	0.45	0.38				0.30	0.27			
12		3	0.3	0.3	0.15	0.01				0.30	0.09			
13		4	0.4	0.4	0.20	0.03				0.30	0.12			
14		5	1.2	1.2	0.62	0.94				0.30	0.37			
15														
16		1	0.5	0.5	0.25	0.07	0.63			0.30	0.15	0.195	0.0387	0.20
17		2	0.7	0.7	0.35	0.18				0.30	0.21			
18		3	0.8	0.8	0.40	0.27	-			0.30	0.24			
19		4	0.6	0.6	0.30	0.11				0.30	0.18			
20														
21	A6.6	1	2.0	1.6	0.80	1.74	5.23	4.58		0.25	0.40	0.253	0.088	0.35
22		2	0.5	0.5	0.25	0.07				0.25	0.13			
23		3	1.0	1.0	0.50	0.52				0.25	0.25			
24		4	1.2	1.2	0.60	0.87				0.25	0.30			
25		5	1.0	1.0	0.50	0.52				0.25	0.25			
26		6	1.3	1.3	0.65	1.06				0.25	0.33			
27		7	0.7	0.7	0.35	0.18				0.25	0.18			
28		8	0.8	0.8	0.40	0.27				0.25	0.20			
29														
30		1	1.1	1.1	0.55	0.69	3.93			0.30	0.33	0.259	0.122	0.47
31		2	0.9	0.9	0.45	0.38				0.30	0.27			
32		3	0.9	0.9	0.45	0.38				0.30	0.27			
33		4	1.0	1.0	0.50	0.52				0.30	0.30			
34		5	0.9	0.9	0.45	0.38				0.30	0.27			
35		6	0.4	0.4	0.20	0.03				0.30	0.12			
36		7	1.8	1.5	0.76	1.54				0.30	0.45			
37		8	0.2	0.2	0.10	0.00				0.30	0.06			
38														
39	A7.2	1	0.4	0.4	0.20	0.03	5.72	5.06		0.30	0.12	0.217	0.120	0.55
40		2	1.5	1.4	0.69	1.24				0.30	0.41			
41		3	1.0	1.0	0.50	0.52				0.30	0.30			
42		4	0.2	0.2	0.10	0.00				0.30	0.06			
43		5	0.5	0.5	0.25	0.07				0.30	0.15			
44		6	1.8	1.5	0.76	1.54				0.30	0.45			
45		7	0.2	0.2	0.10	0.00				0.30	0.06			
46		8	0.3	0.3	0.15	0.01				0.30	0.09			
47		9	1.0	1.0	0.50	0.52				0.30	0.30			
48		10	0.7	0.7	0.35	0.18				0.30	0.21			
49		11	0.6	0.6	0.30	0.11				0.30	0.18			
50		12	0.9	0.9	0.45	0.38				0.30	0.27			
51		13	1.1	1.1	0.55	0.69				0.30	0.33			
52		14	0.4	0.4	0.20	0.03				0.30	0.12			
53		15	0.8	0.8	0.40	0.27				0.30	0.24			
54		16	0.6	0.6	0.30	0.11				0.30	0.18			
55														
56		1	3.0	2.0	0.98	2.74	4.40			0.30	0.59	0.255	0.181	Table
57		2	0.9	0.9	0.45	0.38				0.30	0.27			
58		3	0.4	0.4	0.20	0.03				0.30	0.12			

Figure IV-3. Histogram of size distribution for phosphorite pellets (diameters). The percentage value refers to estimate of CFA grains as a percent of total volume. The number underneath refers to depth below sea floor in meters, along with abbreviated stratigraphic interval. Phi interval ($-\log_2 D$) is translated into millimeters and Wentworth texture classifications on horizontal axis. Recording limit for fine fraction is .02 mm. Small box symbols in Fig. IV-3, 7.2m refer to subgroups of 100-cell fields reported in quarter-phi intervals, composited into the half-phi histograms. The dotted column highlights the 2.5-3.0 phi class mode. In the 9.3m sample the quarter-phi boxes refer to an additional group of samples beyond the population forming the half-phi histogram. The bar represents the textural range *(approximately 20-80 percentile) of sediment exclusive of CFA pellets and clay. The stippled bar (2.5-3.0 phi) is discussed in the text.



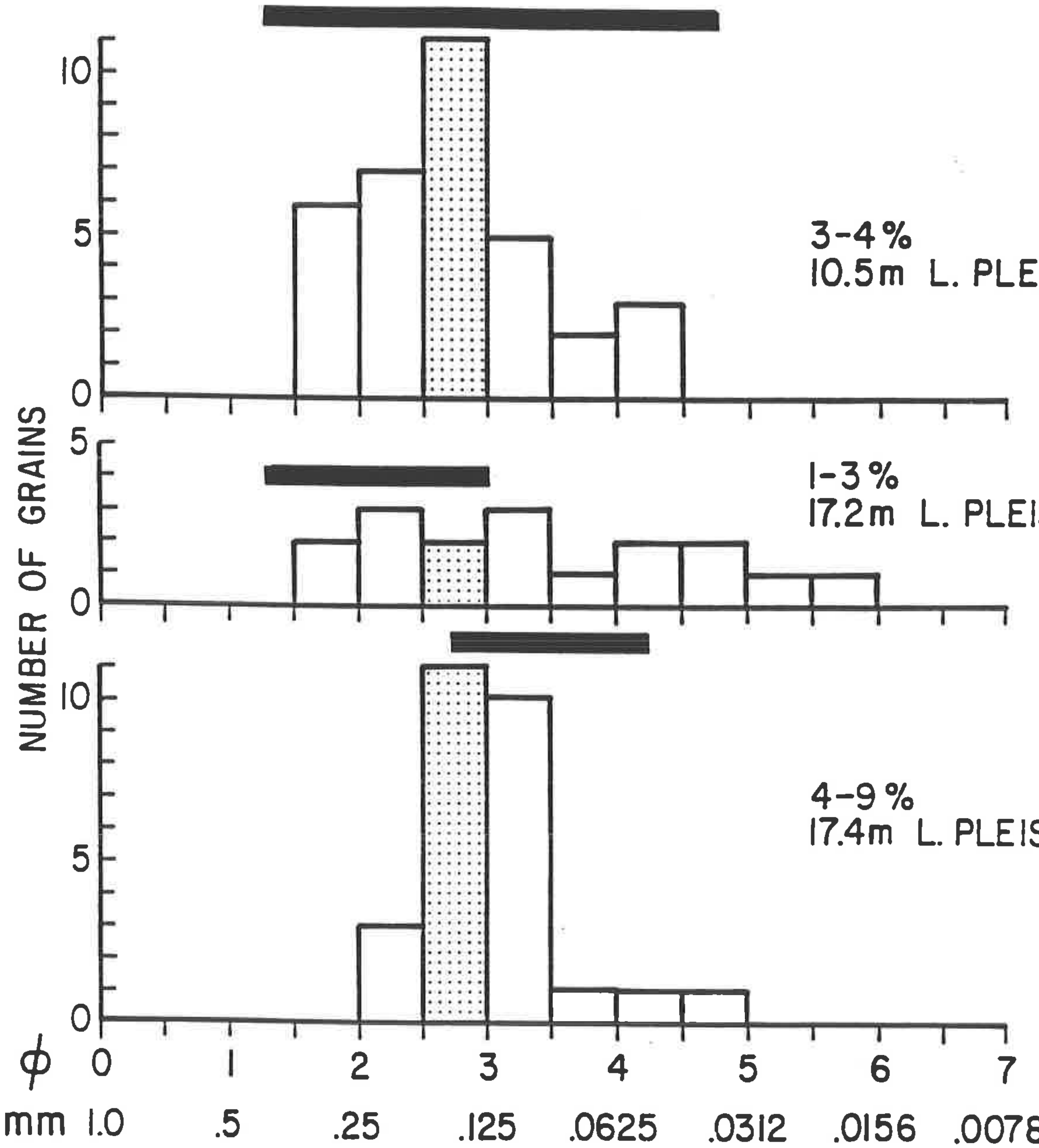


Figure IV-4. Histograms of size distribution for Pleistocene pellets at 10.5, 17.2 and 17.4 m size distributions (see Fig. IV-3 for additional notes.

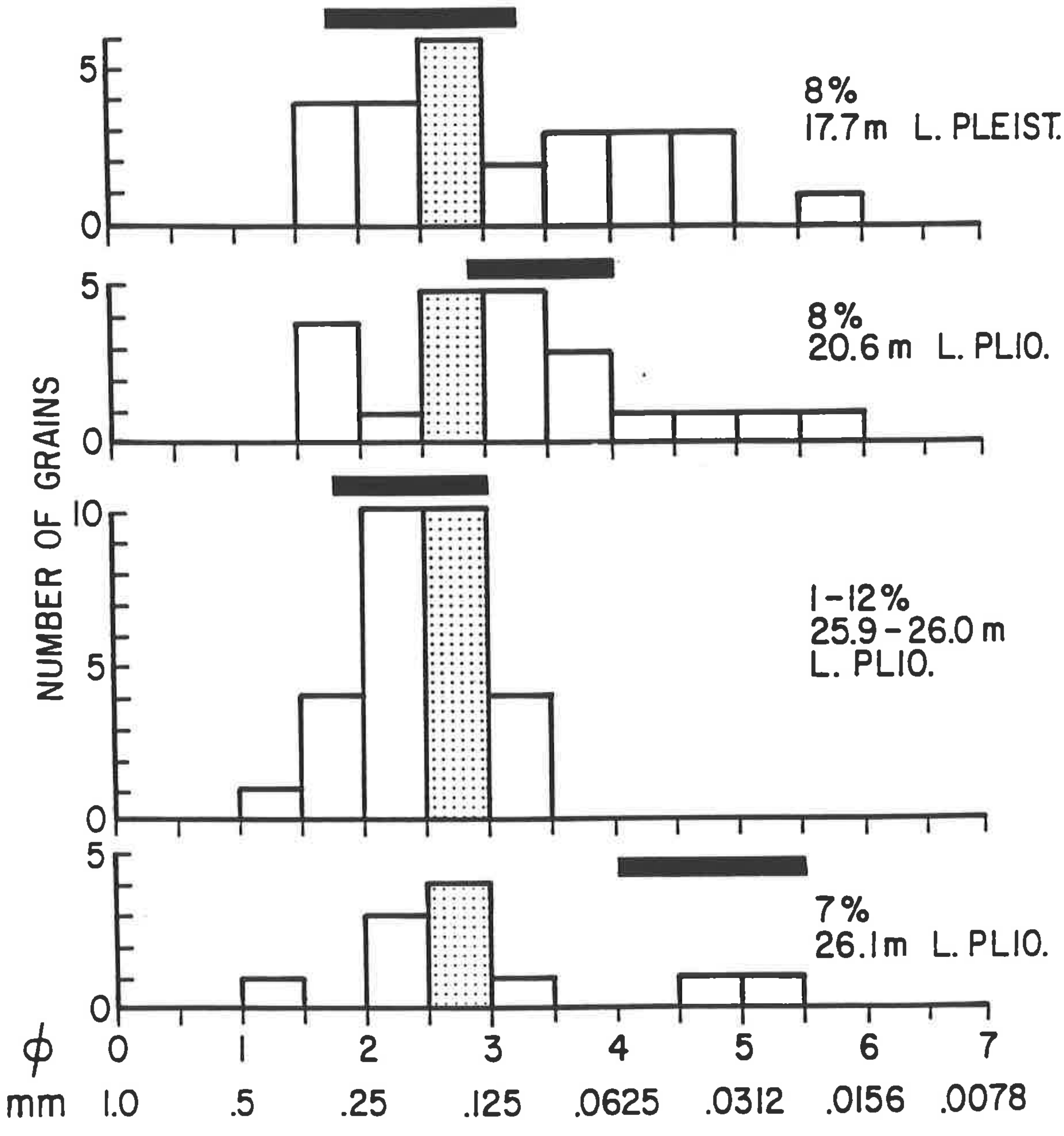


Figure IV-5. Histogram of size distributions for Pliocene and Pleistocene pellets (see Fig. IV-3 for notes).

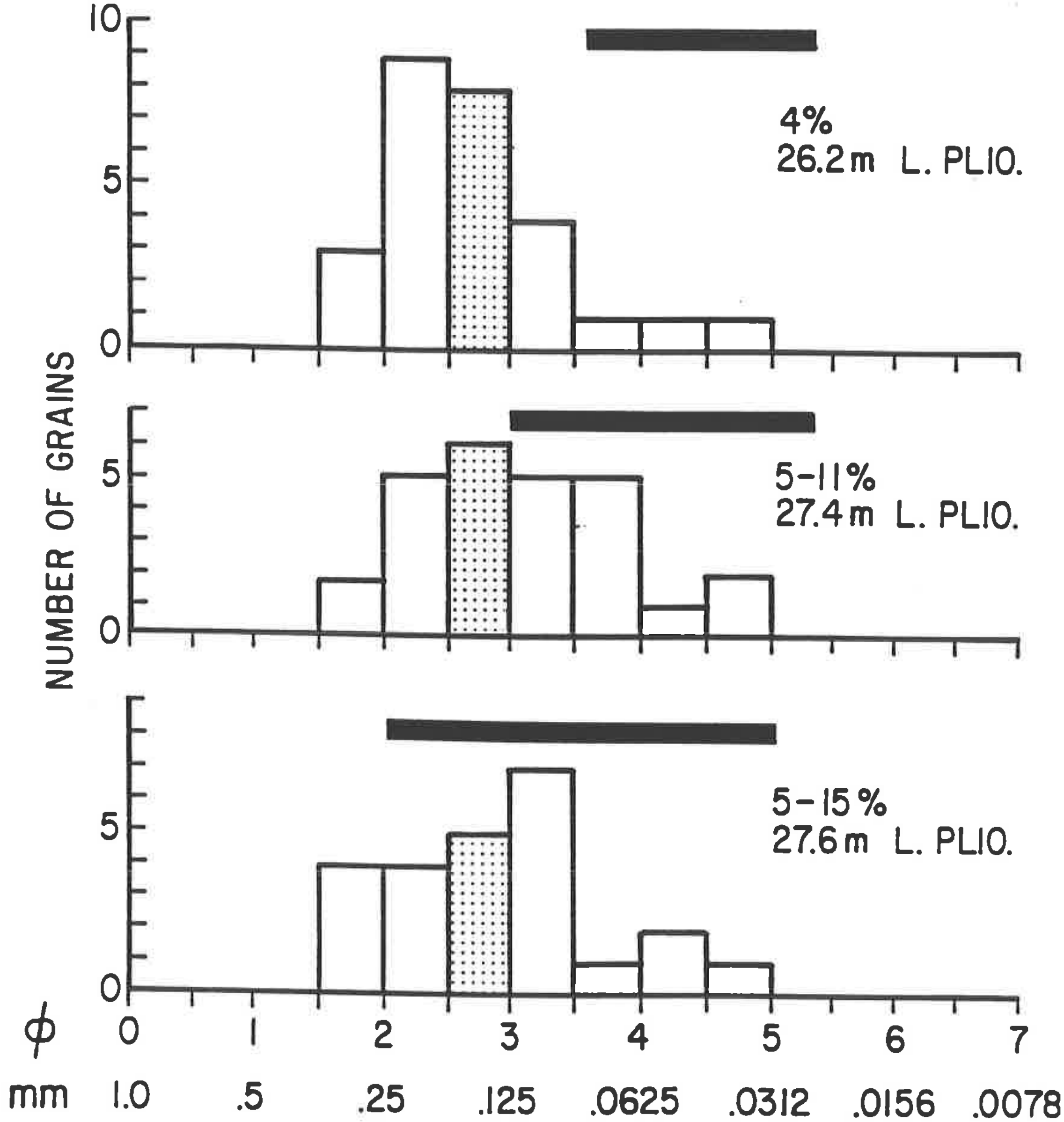


Figure IV-6. Histograms of size distributions for L. Pliocene pellets(see Fig. IV-3 for notes).

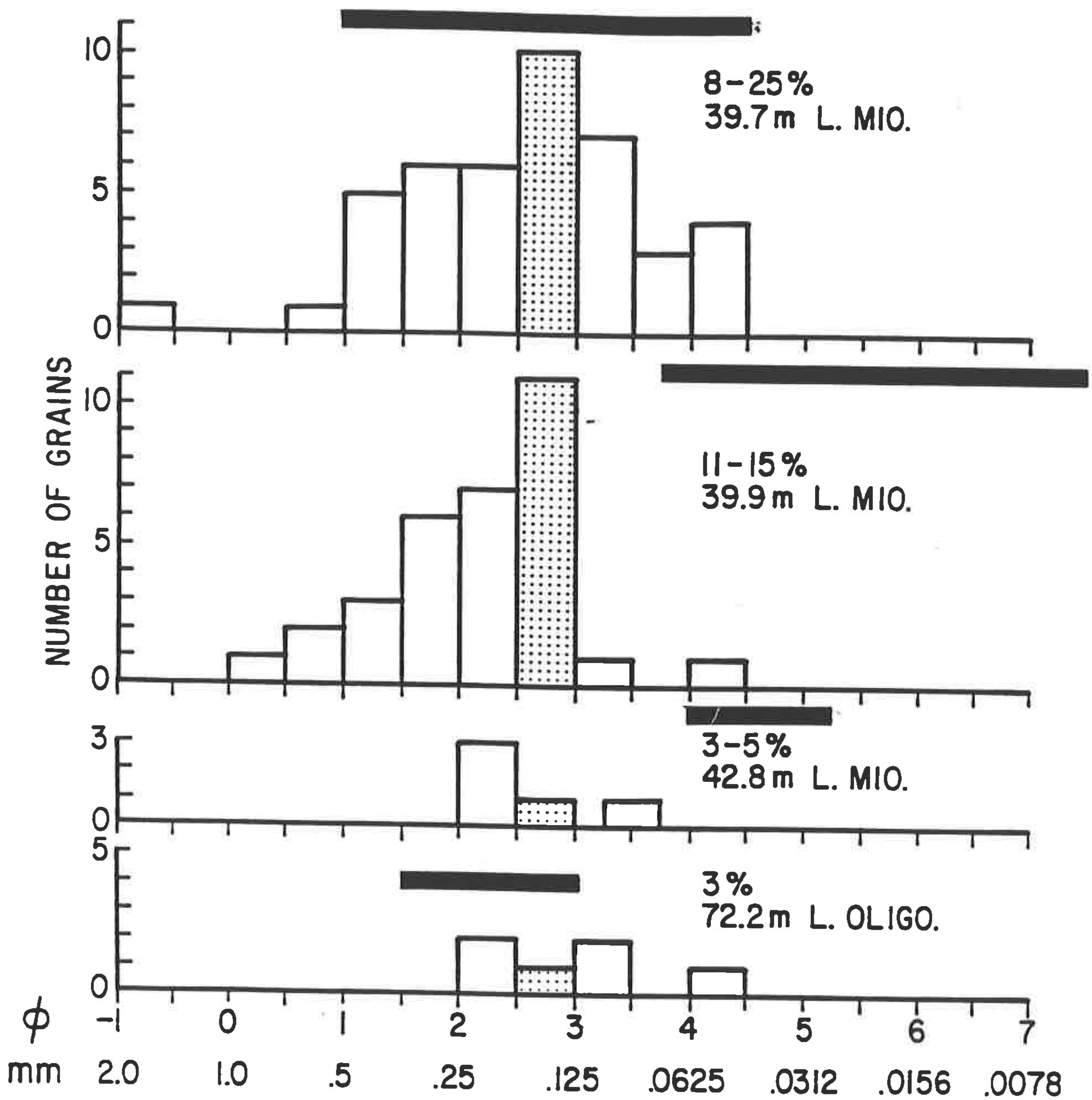


Figure IV-7. Histograms of size distributions for L. Miocene pellets (see Fig. IV-3 for notes).

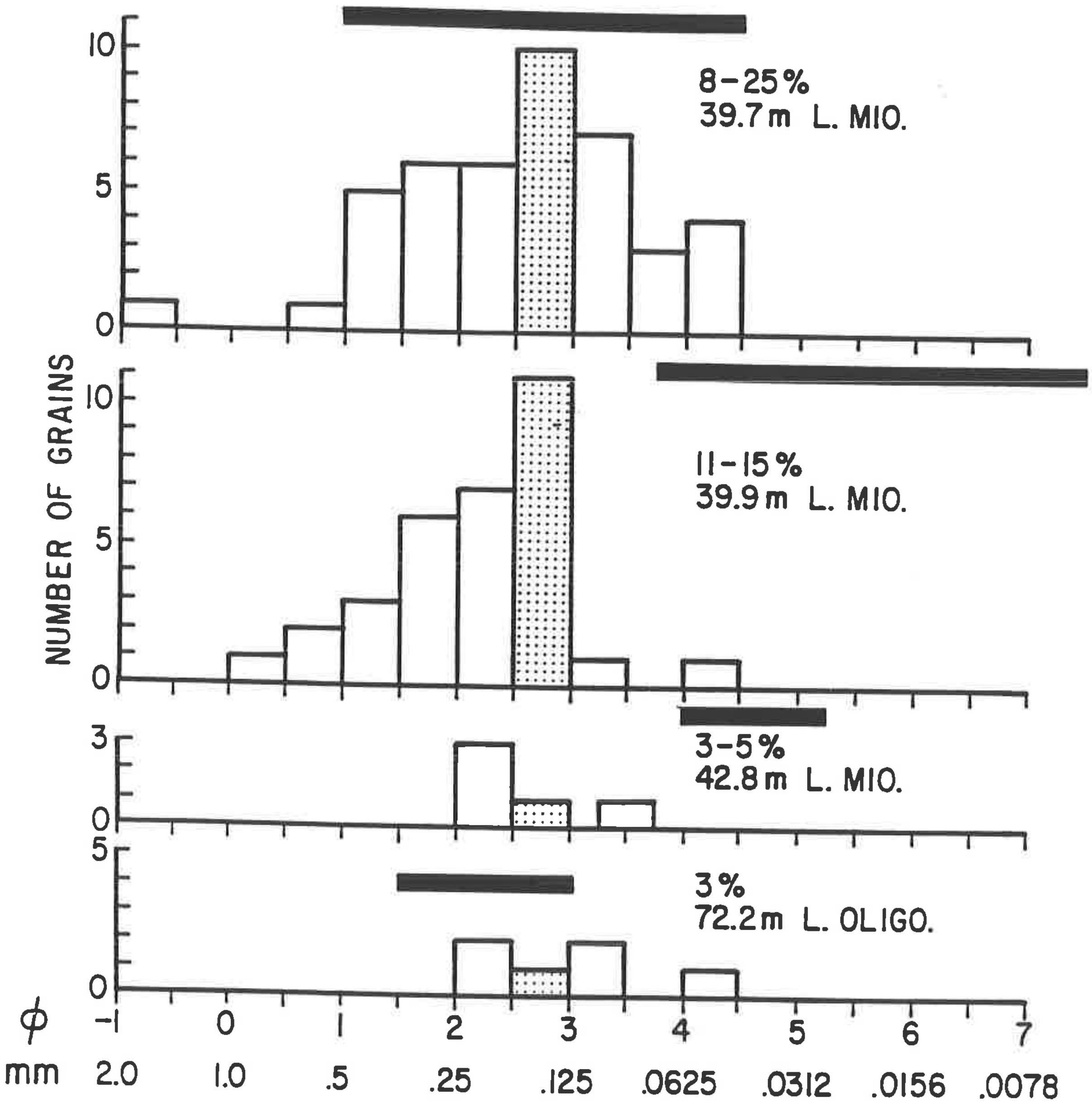


Figure IV-8. Histograms of size distributions for L. Miocene and L. Oligocene pellets (see Fig. IV-3 for notes).

Interpretation of textural distributions for pellets

Except for the uppermost sandy sediments (Fig. IV-3) the textural results show a remarkably consistent size distribution for phosphorite pellets in the investigated sediments. As Cayeux, 1924, 1939; Riggs, 1979 and others have observed the size range of 2.5-3 phi (.25-.125mm) often contains the median distribution of pellet populations. It is stippled in figs. IV-3 to IV-8.

<u>Criteria for primary pellet formation</u>

The phosphorite pellet populations tend to be lognormal with a tail skewed toward finer sizes. The characteristic central tendency of the pellets is found in host sediments that vary in texture from sizes similar to the pellets, to much finer in texture. We postulate that outlier populations of coarser grains dominated by phosphorite pellets deposites must be formed in situ. Any *transport* mechanism that could bring pellets to a site would also be likely to transport quartz or coarser carbonate grains (e.g. shell debris). Thus, the presence of pellets as the dominant phase of a coarser, outlier mode in finer sediments forms the first criterion for identification of primary phosphorite.

The above criterion is suggestive, but does not provide direct evidence of primary origin. However, examination of the finer sediment distributions revealed clearly horizons where there was not only a discrepancy between size distributions of phosphorite and host sediments, whether they were carbonates, clay or silt-size quartz sand-dominated. In addition, phosphorite pellets in the state of formation inside foraminifera were observed. The observations ranged from phosphorite in early or partial stages of formation inside tests, to a calcite test wall surrounding an internal mold of phosphorite, to cases where only delicate remnants of outer test walls adhered to pellets. These clearly could stand virtually no transport without losing the vestigial carbonate test fringes.

An example of a horizon where virtually every foraminiferal test shows some stage of phosphorite formation may be seen in Figure IV-9a-f, from the Middle Miocene of Borehole G. Here the white color is mainly external unphosphatized calcite cell wall or chambers, whereas the buff to brown (gray in the photo) color is phosphorite, confirmed by the phosphomolybdate chemical test. Again, many of these grains have obviously not been transported, else the friable and often weakened shells remnants would have been abraded. In Fig. IV-8b and IV-9e the insides of ostracod tests have developed adhering layers of roughly-textured phosphorite, whereas in IV-9c some radial calcite wall fragments are all that remain of the calcite chambers of a phosphatized benthic foraminifer. In Fig. IV-9f the external carbonate test wall encloses a phosphatized mold. The upper part of the figure is speckled with minute pyrite grains from 20 uM to less than 5uM. uM. In the bottom of this figure globular vitreous phosphorite has been freed of all carbonate but still retains some of the foram test shape.

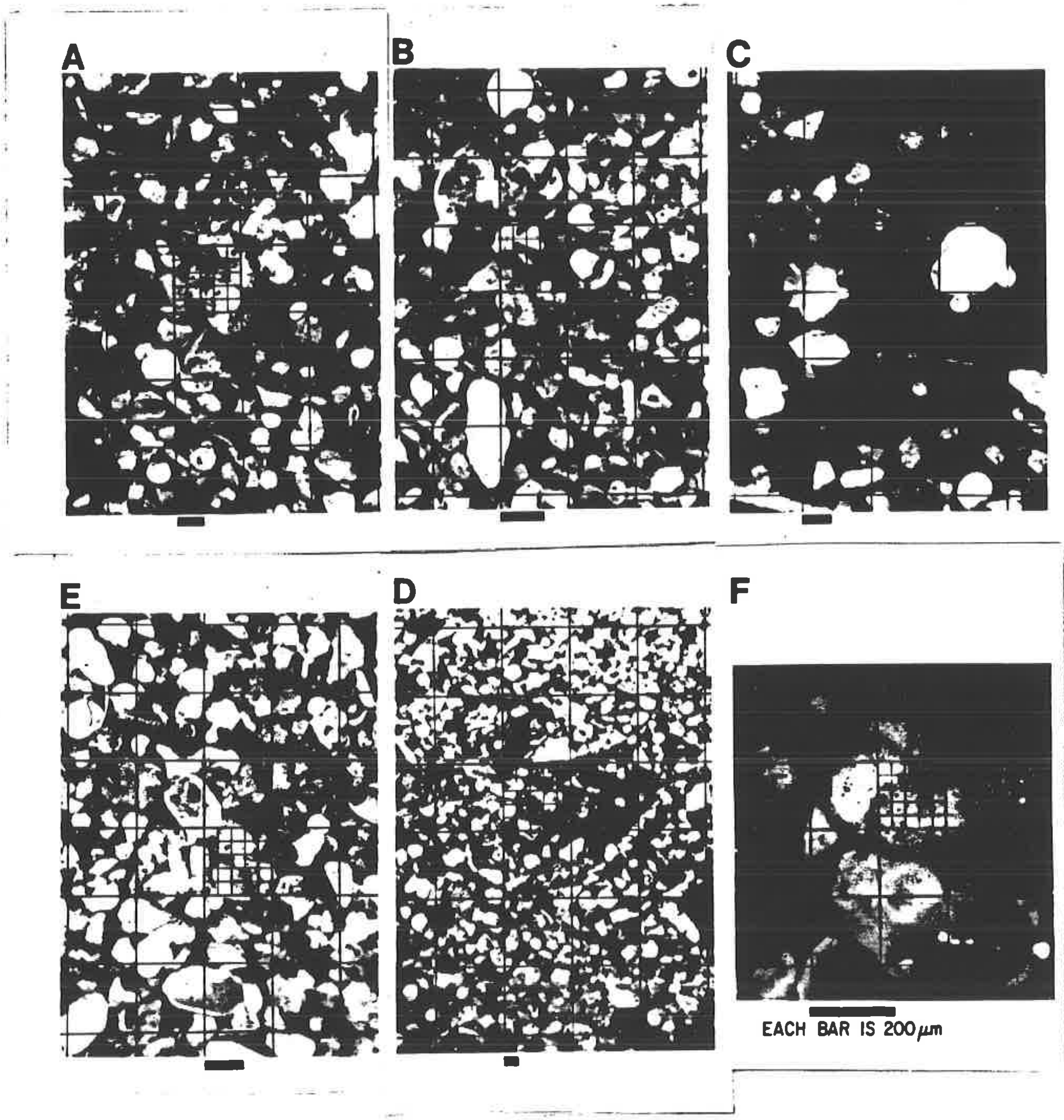


Figure IV-9. Microphotographs of phosphorite grains from Borehole G, about 68m, uppermost Middle Miocene. In general, white signifies calcium carbonate, whereas gray (buff-amber in original samples) represent phosphorite (CFA). Individual photographs are discussed in text. IV-9a: Relatively well-sorted, partly phosphatized foram tests; IV-9b: note ostracode shell with incipient CFA encrustations at upper left; IV-9c: Note largely phosphatized test in left center, with remanent keel or external carbonate structures; 9d: note vitreous-appearing agglomerate in center; 9e: larger ostraode test in lower central area, incipient internal phosphatization; 9f: Upper part of plantonic foram specked with pyrite grains; lower part is a phosphatized mode with remnants of test wall in the upper part.

Whole forams vs. chambers as pellet-formation sites.

The relationship between pellet and foraminiferal test size is not straightforward, because foraminifera tend to be larger than the characteristic pelletal distribution. However, examination of samples in which active primary phosphorite formation is present shows that foraminifera in which a whole mold is created are the exception. In most cases the chamber filling have broken apart to form CFA grains which may have no obvious morphological similarity to the external foraminiferan. The size range of foraminiferal chambers (Fig. IV-9) agrees well with that of typical pelletal distributions, i.e. 100-200 uM. The tail to smaller pelletal sizes found in fine phosphatic substrates may correspond both to smaller chamber fillings as well as phosphatized fillings of juvenile organisms. However, when converted to weight units, the finer fractions make up only a small part of total visible phosphate content.

Secondary alteration of pellets

Microscopic observations show that newly-formed pellets are usually light in color, have a rough exterior, and are virtually structureless internally. Following the primary or insitu formation of pellets in sediments, winnowing or transport often occurs. This causes breakup of foram molds into subgrains formed within chambers, removes any remaining adhering carbonate, and polishes and/or abrades the grains to further cause loss of characteristic morphology. Often a secondary precipitation or phosphate overgrowth state frequently occurs. At this time shell and bone material is phosphatized to a light brown-amber color, and cementation of grains to form aggregates may begin. Fig. IV-9d shows a large, knobby, aggregated phosphorite grain having dimensions about .8 x 1.2 mm, whereas many partly phosphatized white forams (center subdivided grid) are on the order of .2 mm. The recemented grain may be a relic of an earlier generation of sediment that has been partly reworked, whereas the smaller particles may represent a later influx of sediment.

The winnowing, recementation and aggregation process is variable, but most concentrations of phosphorite greater than about 15-20% pellets are clearly characterized by such winnowing or loss of fine fractions, and are especially pronounced at unconformities.

As the winnowing and transport of phosphorite pellets continues, the color of grains becomes darker. In some cases this can be shown by acid leaching to be due to the presence of oxidized iron. Thus, although dark-olive brown color is associated with phosphatic and organic-rich sediments, the darkest colors in the sediments studied here seemed to be more often an indicator of iron, accumulated during reworking and transport.

Fecal pellet origin

As mentioned earlier, fecal pellets have often been linked with phosphorite pellet origin. However, their are many problems with this hypothesis. Fecal pellet morphology tends toward elongated, cylindrical or ellipsoid shapes, almost never spherical bodies (e.g. Porter and Robbins et al, 1984).

Moreover, the wide spectrum of sizes of fecal pellets, particularly the much larger pellets of typical benthic organisms such as polychaete worms, molluscs and gastropods, etc. does not provide a favorable match for the characteristic size range of the phosphorite pellets. Finally, fecal pellets contain only a small proportation of phosphate, so that they do not offer a source for most of the CFA in phosphorite pellets.

Pyrite formation

Pyrite is an omnipresent phase in phosphatic sediments. Foram tests and phosphorite molds show frequent speckling with minute pyrite grains. Upon oxidation, either in the natural environment or as sediment samples become altered upon storage, these pyrites alter to goethite. Sometimes the pyrite grains form small framboids on the order of 5-10 uM within discrete foram tests (Fig. IV-10). Alteration of iron sulfide, when abundant in sediments, may contribute to acidic conditions that cause extensive leaching and etching of carbonates upon oxidation of the substrates. Conversely, the retention of pyrite grains is an indicator that the sediments in question have not been subjected to subaerial exposure, or to shallow groundwater conditions on land. They are particularly prevalent in the offshore Georgia strata, which are regarded as having been deposited in a regional trough (Popenoe et al, 1987, 1991), and thus protected from the above conditions since their formation.

Fig. IV-10. Pyrite framboids within textularid benthic foraminifera test

Discussion of pellet formation in the ocean environment

We conclude that the primary stage of phosphatization involves deposition of organic-rich sediments, as is well discussed in the literature (see Burnett and Riggs, 1991, and references cited therein). From this point primary phosphate pellet formation in our strata appears to take place predominantly inside foraminiferal tests and occasionally other organisms. The key feature appears to be a constrained microenvironment which also shapes the protopellets. In some cases fine carbonate debris inside tests is phosphatized; in other cases chamber walls and other carbonate debris form the nucleus for phosphatization and pellet growth may be incomplete.

In order to preserve organic-rich sediment, which supplies phosphate and limited quantities of carbonate organisms to the phosphorite-generating pore-water environments on the sea floor, a relatively low-energy environment is required. This implies deeper water, such as at least outer-shelf or preferably upper slope, origin. Such conditions are best met under transgressive eustatic conditions of the ocean, noted repeatedly during Tertiary time (Fig. III-14). When the seas recede the finer sediments will be winnowed away, and pellets may be transported, at first only locally, marginally, and then more vigorously. Finally, under major transgressive conditions widespread erosional unconformities will occur. Depending on variable sedimentation, current, and topographic conditions given areas may be sites of accumulation of pellet residues, or these may also be largely eroded. Along the path of the ancestral Gulf Stream warm core eddies spun off from the main flow could be expected to exert special and complex paleooceanographic erosive conditions on the underlying shelf. The fact that changes of sea level of more than 100 m can occur within relatively short geological time intervals helps explain cases where fine-grained beds with pelagic fauna, presumed to be from water depths of 100m or more, may have relatively short vertical separation from coarser beds with evidences of shallow-water origin. It is our presumption that in such cases the finer beds are most likely to serve as the primary sources of phosphorite, which can become reworked and redeposited in shoaling environments.

Although whole-organism phosphatization in such a way as to replicate the original test has been found elsewhere (Manheim et al, 1975), this pattern is little observed in the TACTS sites. Here the most common determinant of pellet size is normally not whole organism tests, but chamber fillings. These may show some resemblence to parent tests immediately after formation, but quickly lose any linkage to biological origin after all original test material is dissolved or abraded. The role of chamber fillings helps account for the frequently skewed size distribution toward smaller pellets. In reworked sediments the fines may be lost through winnowing or recrystallization. Where pelletal phosphorite is exposed at the sediment-water interface, as it is around the Savannah Light area, the Frying Pan Shoals area, North Carolina (Riggs et al, 1990), it may recrystallize and form larger aggregates or even pavements as on the Blake Plateau (Manheim et al, 1980; Ayres and Pilkey, 1981; and Popenoe and Manheim, 1990). Under these conditions the unconsolidated aspect of the deposits discussed above no longer applies.

A given sediment often shows evidence of several formative stages of pellets. In some cases relatively fresh foram tests with little or no phosphatization, older tests with fully-formed pelletal molds, as well as abraded and polished pellets are found. This can be interpreted as reflecting fluctuations in sediment environmental conditions, with the last-preserved condition being a deeper-water or lower-energy phase that permitted preservation of delicate foram tests. The degree of phosphatization is presumed to be largely controlled by the intensiveness of production of organic matter and its retention in the surface sediments long enough to give rise to elevated interstitial water phosphate concentrations.

The reverse condition could be typified by a muddy sediment showing evidence of primary phosphatization, succeeded upward by a coarser, mixed sediment containing dar, polished phosphorite grains, with evidences of reworking at the interface.

The role of pelletal phosphorite in industrial recovery

Sieving tests compared with chemical analyses (Herring and Manheim, 1991); Herring et al, 1991 have shown that in many of the TACTS sediments the phosphorite is dominated by a pelletal habit. This is not necessarily the case in other areas.

The pelletal phosphate fraction from the present province occurs in size ranges smaller than for many industrial phosphorite deposits (Breza et al, 1979; cited in Cathcart et al, 1984), and approaches the limit for beneficiation acceptance (D. Crissinger, 1991, oral communication). However, the *naturally wet* sediment normally disaggregates without grinding, permitting almost complete separation from carbonate and clay admixtures. Standard flotation procedures may permit a high degree of enrichment and recovery from the deposits. Moreover, the ease with which the observed deposits disaggregate with water suggests that they should be especially amenable to recovery through borehole jet mining. However, the bearing capacity of strata that would be required to maintain borehole mining operations (Savanick, 1982) has not yet been investigated.

As suggested in Chapter V, 1991, the uranium content of the unweathered phosphorite pellets is well over 100 ppm. This would offer potential for uranium extraction. In the event of slurry (borehole) mining, we suggest that the problem of uraniferous tailings might be reduced because of the potential availability of subsea caverns to accept return of such products.

Even though the available cores cover less than 10 percent of the penetrated strata, they were originally collected for purposes unrelated to phosphate assessment, and hence could be considered a random population with respect to phosphate enrichment. From the chemical data (Herring and Manheim, 1991) a mean concentration of about 16% CFA or 12.2 bone phosphate of lime (BPL) can be estimated for Miocene TACTS cores. A mean thickness for the Miocene of 30m (Popenoe, 1991) for a 10,000km^2 area off Georgia (to the 30m water depth), will yield more than 50 billion tons of BPL (see also Herring, et al., 1991). Thus, although many uncertainties remain, it is clear that the offshore Georgia province contains vast quantities of phosphorite, which from the sheer mass should not be ignored in discussion of phosphate resources for the future.[1] Boreholes with continuous core recovery will be required to document the detailed phosphate distributions offshore.

V CHEMISTRY OF THE TACTS CORES

By J.R. Herring and F.T. Manheim

Major and trace element analyses of a selection of TACTS samples demonstrate both the distribution of phosphate, its relationship to other mineral and chemical constituents, the composition of the phosphorite pellets (themselves), and other useful parameters, such as content of toxic metals or other undesirable components that may play a role in potential economic processing for phosphate recovery. We present here only a brief review of key chemical features and relationships.

Methods

Major element analyses were performed by C.S. Papp and K.J. Curry of the Denver USGS Laboratories by X-ray fluorescence spectrometry on samples ignited at 920°C, fused with lithium borate (Taggart and others, 1981, 1987) by X-ray fluorescence spectrometry. In addition, H_2O^+ (bound water > 120°C), H_2O^- (hygroscopic moisture), loss on ignition at 900°C were analyzed by standard laboratory methods, total carbon (TOTAL C) was analyzed by a LECO EC 12 automated carbon analyzer using an induction-furnace/thermal conductivity analyzer that combusts splits of the ground samples at 900°C in oxygen. Total total sulfur was also determined by high temperature combustion and titration (LECO elemental analyzer). Major and trace constituents were analyzed by inductively coupled plasma (ICP) emission spectrometry, preceded by standard hydrofluoric acid dissolution (P.H. Briggs). Uranium was determined by fluorometry after sample dissolution, by B.M. Adriann and T.A. Roemer of USGS Denver. A number of samples were sieved into size fractions, which were then analyzed. These are identified in the analytical tables.

The sum of all major elements plus ignition loss consistently approaches a little less than 100 (Table V-2). The elements and components needed to sum to 100%, but which were not routinely analyzed in present data, include Cl, F and S (total sulfur), most of which may be present as SO_3, Much of the Na and Cl and a small part of the S04 can be attributed to original sea water dried with the samples. Ignition loss includes bound water (H_2O^+) of clays and hydrates, loss of CO_2 from carbonates like calcite and dolomite, plus any other volatiles like sulfide and part of chloride. Several analyses of total sulfur are reported in Table V-2. A positive correction, i.e. to be subtracted from the sum, would be required to account for oxygen that would be replaced by the halogens, if, for example, fluorides were to be computed from the phosphate values. A formula to compute fluoride, assuming that all P_2O_5 is in CFA,as well as a selection of other conversion algorithms is given in Table V-1.

Table V-1. Conversion formulae and assumed constants for phosphate and other phases associated with phosphatic sediments. C is CFA(wt. %), D_{CFA} is CFA density, = 2.78 (see discussion in text), and D_{sed} is sediment density, which is variable, depending on depth, water content and cementation. BPL refers to bone phosphate of lime, $Ca_3(P2O_5)_2$, and the conversion from $P2O_5$ is an accepted industry standard. V_f is volume % of carbonate fluorapatite in sediment. The CFA concentrations and fluoride relationship refer to a theoretical pure carbonate fluorapatite (McClelland et al, 1982).

$$P_2O_5 \text{ in CFA} = 34.0$$
$$\text{CFA }(\%) = 2.94 \times P_2O_5$$
$$F(\%) = 0.137 \times P_2O_5$$
$$CO_2 \text{ in CFA} = 6.2$$
$$\text{BPL} = 2.185 \times P_2O_5$$
$$\text{CFA (volume\%)} = (C/D_{CFA})/((C/D) + (1-C/D_{CFA})/D_{sed}))$$
$$P_2O_5(\%) = 1.053V_f/[1.053V_f + (1-V_f)D_{sed}]$$

One final set of data is mentioned here and will not be discussed further. A petroleum-like smell was found at intervals throughout the cores when samples were treated with acid. These indications were particularly noted in the dark, organic-rich layers, often with significant amounts of phosphorite. Jean Whelan and Marta Tarafa of the Woods Hole Oceanographic Institution kindly undertook pyrolysis analysis of samples from Hole B to determine if any migrated or other hydrocarbon was present. The results of the analyses showed pyrolysis values typical for immature sediments, without any evidence of migrated or generated petroleum. Pyrolysis C1-C3 values (methane-ethane-propane) within the Miocene strata indicate significant gas generating potential, especially within dark-brown, foraminiferal shales. The investigators found the pyrolysis curves to track lithology fairly well. The source of the odor remains unknown.

Table V-2. Major element composition of selected bulk and size-fractionated samples, Sites B, D, G, and H.

Sample/Depth	D11.6-D	D11.6-E	D11.6-F	D11.6-G	D21.5-A	D21.5-B	D21.5-C	D21.5-D
Sample Type	T, 18-35	T, 35-80	T, 80-200	T, <200	T	T	T, 35-80	T, 80-200
SiO2 %	8.58	10.6	60.1	54.4	49.2	48.4	33.2	49.1
Al2O3 %	0.67	0.99	3.9	10.2	7.96	8.16	7.3	4.2
CaO %	41.2	43.2	16.2	6.82	12	11.4	20.7	20.8
Fe2O3 %	0.45	1.04	0.38	3.43	2.53	2.65	2.85	1.06
TiO2 %	0.02	0.02	0.11	0.74	0.37	0.37	0.33	0.11
K2O %	0.19	0.26	1.31	1.71	1.6	1.63	1.31	1.1
Na2O %	0.96	1.28	1.29	1.28	1.93	1.9	0.89	1.31
MgO%	0.68	0.9	0.43	2.95	3.26	3.51	3.57	0.99
P2O5 %	21.3	26.6	9.89	2.12	6.33	5.82	11.2	12.6
LOI 900C	12.3	10.3	4.34	15.2	12.7	14.4	14.8	6.41
TOTAL C	1.9	2.56	1.03	4.78	1.97	2.13	3.45	1.67

Sample/Depth	D21.5-E	D33.7-A	D33.7-B	D33.7-C	D44.0-A	D44.0-B	D44.0-C	D44.0-D
Sample Type	T, <200	T	T	T, <200	T	T	T, 80-200	T, <200
SiO2 %	49.5	38.6	38.3	40.3	34.4	33.8	33.1	15
Al2O3 %	10.9	7.48	7.41	8.49	7.41	7.6	7.24	1.44
CaO %	6.31	10.8	10.7	10.1	15.2	14.8	17.1	42.6
Fe2O3 %	3.84	2.97	2.9	3.04	2.83	2.89	2.68	0.65
TiO2 %	0.54	0.32	0.32	0.33	0.31	0.31	0.29	0.07
K2O %	1.9	1.17	1.18	1.13	1.13	1.17	1.05	0.15
Na2O %	1.18	1.43	1.44	0.54	1.17	1.21	0.39	0.49
MgO%	5.04	9.07	9.01	8.85	7.99	8.19	7.02	1.48
P2O5 %	2.34	1.12	1.1	1.15	1.53	1.54	2.88	3.53
LOI 900C	17	25.5	27	23.7	25.3	25.6	26.8	33.3
TOTAL C	3.16	4.38	4.65	4.92	5	5.1	8.34	5.35

Sample/Depth	D55.6-A	D55.6-B	D55.6-C	D55.6-D	D58.8-A	D58.8-B	D58.8-C	D58.8-D
Sample Type	T	T	T, 80-200	T, <200	T	T	T, 18-35	T, 35-80
SiO2 %	40.5	41	40.8	42.5	14.4	13.4	4.94	3.43
Al2O3 %	6.56	6.8	6.12	7.04	2.33	2.16	1.07	0.54
CaO %	10.3	9.93	11	9.85	36.9	38	45.7	47.7
Fe2O3 %	2.21	2.32	2.15	2.38	0.78	0.71	0.38	0.3
TiO2 %	0.32	0.32	0.29	0.33	0.1	0.09	0.02	0.02
K2O %	0.89	0.91	0.74	0.87	0.32	0.29	0.09	0.08
Na2O %	1.57	1.72	0.47	0.74	1.5	1.49	1.18	1.2
MgO %	8.6	8.65	7.42	8.66	2.69	2.54	1.29	1.14
P2O5 %	1.77	1.71	3.21	1.82	21.5	22.4	27.9	29
LOI 900C	26.8	25.9	25.9	25.1	15.1	14.8	12	11.6
TOTAL C	5	5.07	10.39	5.41	3.57	3.45	2.99	2.82

Sample/Depth	D58.8-E	D58.8-F	F18.9-A	F18.9-B	F18.9-C	G69.5-A	G69.5-B	G69.5-C
Sample Type	T, 80-200	T, <200	T		T	T	T	T
SiO2 %	6.93	40.5	52.9	51.4	51.8	25.5	22.2	23.8
Al2O3 %	0.65	7.16	7.86	7.97	8.52	5.3	4.49	4.82
CaO %	45.7	11.8	12.3	12.7	10.2	20.7	24.6	23.1
Fe2O3 %	0.28	2.15	2.02	2.14	2.41	1.82	1.51	1.58
TiO2 %	0.02	0.33	0.38	0.41	0.44	0.24	0.21	0.21
K2O %	0.14	0.8	1.39	1.29	1.46	0.64	0.48	0.59
Na2O %	1.2	0.78	2.06	2.02	2.11	1.3	1.2	1.28
MgO %	1.09	6.99	2.62	2.84	4	9.06	8.19	8.01
P2O5 %	28	3.92	3.11	2.57	1.86	7.4	10.2	9.83
LOI 900C	11.7	24.3	13.5	14.5	15.7	26.6	25.4	24.6
TOTAL C	3.08	6.21	2.71	2.89	2.88	5.44	5.31	5.16

Sample/Depth	G69.5-D	G69.5-E	G69.5-F	G69.6-A	G69.6-B	G69.6-C	G69.6-D	G69.6-E
Sample Type	T, 35-80	T, 80-200	T, <200	T	T	T, 18-35	T, 35-80	T, 80-200
SiO2 %	3.11	4.79	32.2	11.5	9.97	3.94	1.98	5.69
Al2O3 %	0.55	0.68	6.7	1.89	1.6	0.34	0.32	0.57
CaO %	48.1	46.9	14.1	40.6	42.1	48.7	49.5	47.4
Fe2O3 %	0.32	0.3	2.17	0.58	0.55	0.26	0.23	0.23
TiO2 %	0.02	0.02	0.31	0.08	0.06	0.02	0.02	0.02
K2O %	0.07	0.11	0.79	0.26	0.22	0.06	0.06	0.14
Na2O %	1.12	1.08	0.62	1.36	1.4	1.05	1.14	1.18
MgO %	1.22	1.18	10.9	2.07	2.01	1.02	0.91	0.88
P2O5 %	29.5	28.9	2.31	25	25.9	30.2	30.7	29.5
LOI 900C	11.6	11.6	28.1	13.1	12.6	10.6	10.6	11.2
TOTAL C	3.1	2.94	6.67	2.99	2.93	2.95	2.85	2.83

Sample/Depth	G69.6-F	H37.6-A	H37.6-B	H37.6-C	H37.6-D	H37.6-E	H37.6-F	H37.6-G
Sample Type	T, <200	T	T	T, >18	T, 18-35	T, 35-80	T, 80-200	T, <200
SiO2 %	42.1	35.1	13.8	18.2	34.9	23.2	12	10.7
Al2O3 %	7.93	7.91	1.59	0.88	0.75	0.63	1.36	2.37
CaO %	9.35	14.7	42.9	40.2	33.8	40.5	44.5	44.9
Fe2O3 %	2.21	2.96	0.76	0.39	0.66	0.51	0.45	0.89
TiO2 %	0.35	0.33	0.06	0.03	0.02	0.02	0.03	0.11
K2O %	0.9	1.18	0.13	0.16	0.12	0.13	0.17	0.29
Na2O %	0.93	0.48	0.46	0.21	0.15	0.31	0.51	0.21
MgO %	7.52	8.29	1.54	1.03	1.38	1.23	1.15	1.64
P2O5 %	4.38	1.54	2.92	1.46	0.77	4.38	9.05	0.33
LOI 900C	23.1	25.6	34.3	27.1	27	28.5	28	38.1
TOTAL C	5.21	8.94	8.31	7.47	7.4	7.87	7.71	11.08

Sample/Depth	H43.4-A	H43.4-B	H43.4-C	H43.4-D	H43.4-E	H43.4-F	H43.4-G	H43.4-H
Sample Type	T	T	T	T, >18	T, 18-35	T, 35-80	T, 80-200	T, <200
SiO2 %	21.3	21.4	22.3	11.2	10.1	7.29	24.3	17.9
Al2O3 %	2.01	1.93	2.03	1.03	0.98	0.82	1.32	2.87
CaO %	39.3	39.3	38.7	45.5	47.8	49.9	38.6	40.8
Fe2O3 %	0.63	0.61	0.59	0.33	0.31	0.38	0.48	0.89
TiO2 %	0.16	0.15	0.15	0.06	0.04	0.02	0.06	0.17
K2O %	0.35	0.34	0.36	0.23	0.18	0.14	0.42	0.45
Na2O %	0.55	0.53	0.59	0.33	0.27	0.19	0.62	0.38
MgO %	1.33	1.32	1.26	1.08	1.17	1.29	1.04	1.64
P2O5 %	3.83	4.47	3.8	2.01	1.47	1.15	8.5	0.85
LOI 900C	29.5	28.8	28.7	32.2	37	38.9	23.2	33.6
TOTAL C	7.87	7.96	7.83	8.74	10.45	10.6	6.3	8.75

Sample/Depth	H49.4-A	H49.4-B	H49.4-C	H49.4-D	H58.4-A	H58.4-B	H58.4-C	H58.4-D
Sample Type	T	T	T, 80-200	T, <200	T	T	T, 80-200	T, <200
SiO2 %	68.8	69.3	79.1	48	73.5	73.8	82.2	62.6
Al2O3 %	4.98	5.07	3.71	8.57	6.48	6.31	5.15	8.73
CaO %	8.88	8.78	7.11	12	6.04	6.05	4.54	8.11
Fe2O3 %	1.01	1.02	0.32	2.76	1.15	1.11	0.32	2.43
TiO2 %	0.46	0.46	0.15	0.59	0.52	0.49	0.12	0.87
K2O %	1.33	1.31	1.31	1.58	1.57	1.56	1.71	1.62
Na2O %	1.41	1.41	1	1.2	1.84	1.77	1.35	1.52
MgO %	1.35	1.37	0.33	4.2	0.61	0.59	0.22	1.17
P2O5 %	4.03	3.93	4.07	3.15	2.13	2.18	2.29	1.93
LOI 900C	6.17	5.94	2	16	4.74	4.91	1.29	9.09
TOTAL C	1.45	1.53	0.49	4.85	1.34	1.35	0.32	3.02

Table V-3. Major and trace element chemistry of samples from sites E, F, and G. Trace elements by ICP spectrometry, except U, H20, S.

Field#	E120L	E190L	E200H	F0.5L	F39.5L	F88.5H	F129.5L	F151L
Ref#	E36.6	E57.9	E61.0	F0.15	F12.0	F27.0	F39.5	F46.0
Major Constituents								
SiO2	5.04	27.4	17.2	90.4	17.1	23.3	42.9	23.8
Al2O3	1.15	3.81	2.88	0.58	1.03	3.52	8.01	4.64
Fe2O3	1.02	1.30	0.85	0.31	0.87	1.12	3.12	1.80
MgO	0.43	2.83	3.63	0.25	1.91	1.75	6.56	3.63
CaO	50.5	28.2	33.4	3.49	41.4	31.9	9.22	29.40
Na2O	0.59	1.49	1.72	0.36	0.36	1.85	2.27	1.13
K2O	0.10	0.41	0.21	0.19	0.02	0.58	1.25	0.30
TiO2	0.12	0.13	0.12	0.07	<.02	0.12	0.35	0.18
P2O5	35.1	9.99	19.5	0.15	2.28	19.8	1.90	2.15
LOI(900oC)	4.96	21.7	19.6	3.39	33.4	15.1	24.3	30.50
Sum	99.01	97.26	99.11	99.19	98.37	99.04	99.88	97.53
Other Constituents								
H2O+	1.73	3.87	5.00	0.34	1.28	4.00	7.09	4.36
H2O-	0.51	2.87	3.41	0.10	0.67	2.76	4.96	2.08
TotS	0.23	1.06	1.29	0.05	0.57	1.38	*	0.77
Trace Elements								
U(ppm)	140	46	40	0.6	7.8	63	11	8.2
Ba	60	133	105	259	39	145	191	338
Cd	18	5	16	<4	5	24	6	<4
Ce	112	72	34	12	20	60	41	32
Co	5	56	69	71	192	53	19	113
Cr	77	176	201	13	160	198	216	124
Cu	9	22	23	8	10	28	18	10
Eu	4	5	<4	<4	<4	<4	<4	<4
La	101	101	69	9	17	65	30	29
Li	<4	16	21	<4	5	11	50	24
Mn	256	60	32	63	58	46	140	94
Mo	<4	10	5	<4	5	28	5	<4
Nd	104	100	62	9	31	65	27	37
Ni	12	46	31	<4	33	34	38	19
Pb	12	13	<8	34	<8	15	9	13
Sc	9	10	15	<4	5	12	10	7
Sr	702	1350	2090	199	1010	1910	366	794
Th	<8	<8	<8	<8	<8	<8	<8	<8
Ti	0.08	0.07	0.07	0.04	0.03	0.06	0.2	0.11
V	91	58	52	<4	18	43	116	65
Y	183	233	163	5	22	137	29	37
Yb	12	14	11	<2	<2	8	<2	3
Zn	138	71	148	<4	13	127	99	41

Field#	F160L	F171L	F180.5l	F181L	F210.1L	F230L	F259L	F278.5L
Ref#	F48.8	F52.1	F55.0	F55.2	F64.1	F70.1	F79.0	F84.9
Major Constituents								
SiO2	28.7	33.1	7.60	7.80	19.8	19.6	30.9	27.4
Al2O3	2.65	2.87	1.15	1.26	2.02	2.59	4.67	4.00
Fe2O3	1.16	0.64	0.49	0.46	1.09	0.63	0.68	0.64
MgO	2.15	4.52	2.39	2.36	3.41	1.46	1.35	2.55
CaO	30.8	25.2	42.6	42.5	34.8	37.6	30.4	31.4
Na2O	1.27	1.42	1.53	1.53	1.49	1.38	1.52	1.35
K2O	0.37	0.43	0.08	0.07	0.42	0.28	0.54	0.40
TiO2	0.07	0.11	0.02	<0.02	0.10	0.14	0.15	0.14
P2O5	10.0	13.7	26.1	26.2	19.1	13.9	4.65	4.26
LOI(900oC)	21.1	17.3	15.7	15.8	13.3	19.4	23.3	25.9
Sum	98.27	99.29	97.66	97.98	95.53	96.98	98.16	98.04
Other Constituents								
H2O+	3.19	4.21	4.04	3.98	2.59	2.87	2.33	2.14
H2O-	2.13	2.57	2.41	2.69	1.42	1.58	1.38	1.73
TotS	0.79	0.87	1.29	1.24	1.03	0.91	0.53	0.53
Trace Elements								
U(ppm)	48	54	76	65	110	32	20	22
Ba	132	170	68	164	3350	118	203	250
Cd	5	8	9	7	4	<4	<4	<4
Ce	69	37	40	36	19	27	31	31
Co	87	92	11	25	1180	30	36	310
Cr	170	143	169	166	105	118	98	83
Cu	26	26	23	18	15	10	7	6
Eu	5	<4	<4	<4	<4	<4	<4	<4
La	100	68	94	93	35	54	38	41
Li	10	9	9	8	10	14	10	15
Mn	64	53	20	19	181	43	61	104
Mo	10	30	<4	<4	<4	7	4	<4
Nd	97	59	81	79	37	47	38	45
Ni	31	29	34	31	38	23	19	25
Pb	18	19	<8	<8	42	<8	13	18
Sc	9	8	14	14	7	8	6	6
Sr	1310	1340	2650	2510	1510	1670	961	906
Th	<8	<8	<8	<8	<8	<8	<8	<8
Ti	0.05	0.06	0.03	0.03	0.06	0.07	0.09	0.09
V	54	48	43	42	43	31	36	38
Y	236	169	237	238	65	108	62	65
Yb	14	111	15	15	4	6	4	4
Zn	56	94	111	103	53	47	32	20

Field#	G69.5H	G125H	G166H	G197H	G209H	G216.5H	G217H	G219H
Ref#	G21.2	G38.1	G50.6	G60.1	G63.7	G66.0	G66.2	G66.8
Major Constituents								
SiO2	11.3	69.1	70.3	55.0	39.2	12.5	10.8	21.2
Al2O3	1.86	6.80	7.09	4.70	2.73	1.63	1.35	2.16
Fe2O3	0.70	1.37	1.30	1.02	0.91	0.63	0.58	0.55
MgO	0.46	0.72	0.61	0.77	1.63	3.90	3.04	3.07
CaO	44.2	7.05	6.13	16.6	26.4	38.6	41.2	34.0
Na2O	1.10	1.90	1.89	1.62	1.34	1.30	1.35	1.36
K2O	0.53	1.67	1.72	1.15	0.72	0.16	0.13	0.37
TiO2	0.08	0.47	0.46	0.36	0.07	0.04	0.04	0.09
P2O5	31.1	3.97	3.45	10.4	15.0	22.1	24.3	19.5
LOI(900oC)	6.60	5.92	5.62	7.26	9.83	17.2	15.9	15.9
Sum	97.93	98.97	98.57	98.88	97.83	98.06	98.69	98.2
Other Constituents								
H2O+	1.93	2.41	2.38	2.63	3.17	4.44	4.26	4.44
H2O-	0.57	1.09	0.99	0.90	1.11	2.04	1.67	1.40
TotS	0.88	0.53	0.54	0.80	0.91	1.08	1.20	1.07
Trace Elements								
U(ppm)	140	24	22	40	64	68	63	56
Ba	118	368	383	360	279	88	599	132
Cd	121	6	7	15	5	9	8	14
Ce	24	72	83	137	86	41	46	41
Co	4	236	216	50	24	28	17	32
Cr	986	109	92	123	159	166	156	173
Cu	97	14	10	12	22	21	21	26
Eu	<4	<4	<4	5	5	<4	<4	<4
La	113	51	50	106	124	93	98	81
Li	10	12	11	9	8	7	6	7
Mn	86	126	135	102	72	27	27	32
Mo	13	9	7	7	9	7	7	14
Nd	70	52	47	103	112	81	87	70
Ni	156	14	13	21	36	29	31	45
Pb	16	25	29	14	12	<8	<8	<8
Sc	6	7	7	10	10	12	12	10
Sr	982	467	413	989	1450	2000	2180	1770
Th	<8	10	12	13	10	<8	<8	<8
Ti	0.04	0.25	0.23	0.15	0.04	0.04	0.03	0.05
V	1660	38	33	29	46	47	39	55
Y	156	67	64	159	297	234	250	205
Yb	7	5	4	10	17	14	15	13
Zn	1480	18	<4	62	71	103	104	147

Field#	G228H	G228.5CH	G228.5H	G259CH	G260H	G269H
Ref#	G69.5	G69.7	G69.7	G78.0	G79.3	G82.0
Major Constituents						
SiO2	9.72	9.30	17.7	17.7	16.8	23.4
Al2O3	1.82	1.56	2.57	2.48	2.27	3.46
Fe2O3	0.68	0.50	0.80	0.74	0.72	1.15
MgO	2.97	1.79	3.27	3.08	2.44	2.98
CaO	41.1	42.3	35.3	35.1	35.7	30.7
Na2O	1.51	1.56	1.43	1.42	1.53	1.51
K2O	0.17	0.19	0.31	0.29	0.30	0.51
TiO2	0.07	0.06	0.10	0.09	0.09	0.17
P2O5	24.5	26.5	21.0	20.9	22.5	18.7
LOI(900oC)	15.7	14.5	16.4	17.2	15.3	17.2
Sum	98.24	98.26	98.88	99.0	97.65	99.78
Other Constituents						
H2O+	*	4.74	5.01	5.00	*	*
H2O-	*	1.80	1.92	2.26	*	*
TotS	*	1.30	1.25	1.22	1.33	*
Trace Elements						
U(nom)	76	70	51	64	72	79
Ba	65	72	325	83	2290	119
Cd	18	23	9	9	10	12
Ce	36	29	49	50	44	45
Co	29	46	20	51	29	22
Cr	146	192	200	200	189	195
Cu	16	20	16	16	17	19
Eu	<4	<4	<4	<4	<4	<4
La	55	51	89	93	85	70
Li	14	11	13	12	12	17
Mn	31	20	27	26	33	42
Mo	13	14	9	8	7	16
Nd	55	51	80	80	77	63
Ni	31	44	34	33	28	41
Pb	<8	<8	<8	10	9	<8
Sc	11	12	12	11	12	11
Sr	2200	2430	1890	1900	2060	1630
Th	<8	<8	<8	<8	<8	<8
Ti	0.05	0.04	0.03	0.05	0.06	0.08
V	38	57	52	53	44	55
Y	123	123	208	211	198	156
Yb	8	8	12	12	12	10
Zn	142	180	122	106	135	140

Table V-4. Supplementary total carbon values for Boreholes E, F, and G. The MESS samples refer to laboratory standards for organic carbon.

Sample/Depth	TOTAL C %
E61.0-A	3.81
E61.0-B	3.77
F27.0-A	2.56
F27.0-B	2.47
G38.1-A	1.18
G38.1-B	1.14
G50.6-A	1.05
G50.6-B	1.06
G60.0-A	1.52
G60.0-B	1.48
G63.7-A	2.11
G63.7-B	2.11
G66.1-A	3.09
G66.1-B	3.10
G66.8-A	3.93

Sample/Depth	TOTAL C %
G66.8-B	3.87
G69.5-A	3.26
G69.5-B	3.30
G69.6-A	2.87
G69.6-B	2.86
G69.7-A	3.25
G69.7-B	3.31
G78.9-A	3.22
G78.9-B	3.24
G79.2-A	2.90
G79.2-B	2.91
G82.0-A	3.2
G82.0-B	3.19
MESS-1/BL	1.37
MESS-1	2.82

Table V-5. Major and trace element composition of end-member phases.

PHASE	High Silica		High P2O5			High Clay		High MgO		High CaCO3	
Sample/Depth	B3.0	B4.1	G69.6-A	G69.6-B	B24.8	D21.5	D11.6	B88.1	G69.5	H94.2-A	H94.2 B
Major Elements (%) †											
SiO2 %	94.0	89.1	3.94	1.98	2.36	49.5	54.4	25.9	32.2	4.4	3.89
Al2O3 %	1.67	1.5	0.34	0.32	0.28	10.9	10.2	4.88	6.7	0.62	0.45
CaO %	0.44	3.53	48.7	49.5	48.7	6.31	6.82	18.8	14.1	51.8	52.7
Fe2O3 %	0.56	0.34	0.26	0.23	0.23	3.84	3.43	1.66	2.17	0.50	0.35
TiO2 %	0.18	0.07	0.02*	0.02*	0.02*	0.54	0.74	0.23	0.31	0.02*	0.02*
K2O %	0.43	0.52	0.06	0.06	0.07	1.9	1.71	0.50	0.79	0.11	0.09
Na2O %	0.37	0.42	1.05	1.14	1.34	1.18	1.28	1.46	0.62	0.15	0.15
MgO %	0.22	0.38	1.02	0.91	1.14	5.04	2.95	11.4	10.9	0.99	0.74
P2O5 %	0.13	0.14	30.2	30.7	30.0	2.34	2.12	0.79	2.31	0.64	0.64
LOI 900C	1.25	3.29	10.6	10.6	11.1	17.0	15.2	32.0	28.1	41.0	41.0
TOTAL C	0.07	0.72	2.95	2.85	2.92	3.16	4.78	7.52	6.87	11.22	11.22
SUM	99.25	99.27	96.19	95.46	95.24	98.55	98.85	97.62	98.2	100.23	100.03
Trace Elements (ppm)											
Ag	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*	2*
As	10*	10*	10*	10*	10*	30	20	10*	30	10*	10*
Ba	130	1100	49	45	33	240	270	100	110	17	25
Be	1*	1*	1*	1*	1*	2	2	1*	1*	1*	1*
Bi	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*
Cd	2*	2*	20	21	5	7	15	2*	15	2*	2*
Ce	15	7	17	23	38	55	71	22	22	12	5
Co	2	2	2	2	2	6	6	4	4	3	3
Cr	8	17	67	69	130	230	220	190	160	66	27
Cu	1*	1*	14	13	23	24	32	11	37	9	11
Eu	2*	2*	2*	2*	4	2*	2*	2*	2*	2*	2*
Ga	4*	4*	4*	4*	4*	15	12	8	9	4*	4*
Ho	4*	4*	4*	4*	6	4*	4*	4*	4*	4*	4*
La	8	6	29	40	89	32	42	17	16	19	13
Li	7	4	4	3	4	43	30	43	56	7	4
Mn	68	39	15	15	12	170	220	92	67	64	38
Mo	2	2	10	10	5	56	40	3	43	2	3
Nb	4*	4*	4*	4*	4*	5	5	4*	4*	4*	4*
Nd	8	4	17	27	71	28	43	12	12	13	9
Ni	4	2	16	20	27	37	55	30	60	13	13
Pb	4*	10	4*	4*	4*	12	15	5	8	4*	4*
Sc	2*	2*	9	12	13	11	11	7	8	6	5
Sn	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*	10*
Sr	52	200	2400	2700	2500	310	320	490	320	1200	1300
Ta	40*	40*	40*	40*	40*	40*	40*	40*	40*	40*	40*
Th	4*	4*	4*	4*	6	8	9	5	4*	4*	4*
U	100*	100*	100*	100*	100*	100*	100*	100*	100*	100*	100*
V	14	9	16	19	30	160	110	84	120	28	16
Y	4	4	72	110	280	35	48	16	19	37	20
Yb	1*	1*	5	7	17	3	4	1*	1*	1*	1*
Zn	6	23	140	140	86	110	94	60	190	26	21

† Sum includes all components except Total C

Table V-6. Mean values of major-element composition for Pliocene and Miocene samples.

Major Elements (%)†	Plio(avg)	Mio(avg)	≤200mesh
SiO2 %	51.22	33.81	37.88
Al2O3 %	1.67	4.99	6.58
CaO %	22.95	21.33	18.26
Fe2O3 %	0.64	1.56	2.08
TiO2 %	0.09	0.24	0.38
K2O %	0.37	0.73	0.96
Na2O %	0.49	1.65	0.85
MgO %	1.19	4.96	5.22
P2O5 %	2.06	5.59	2.31
TOTAL C	4.89	4.97	6.08
LOI 900C	18.13	23.13	24.13
SUM	98.81	97.99	98.65

† Sum includes all components except Total C

Figure V-1. Percentage of phosphorite as CFA in selected TACTS borings.

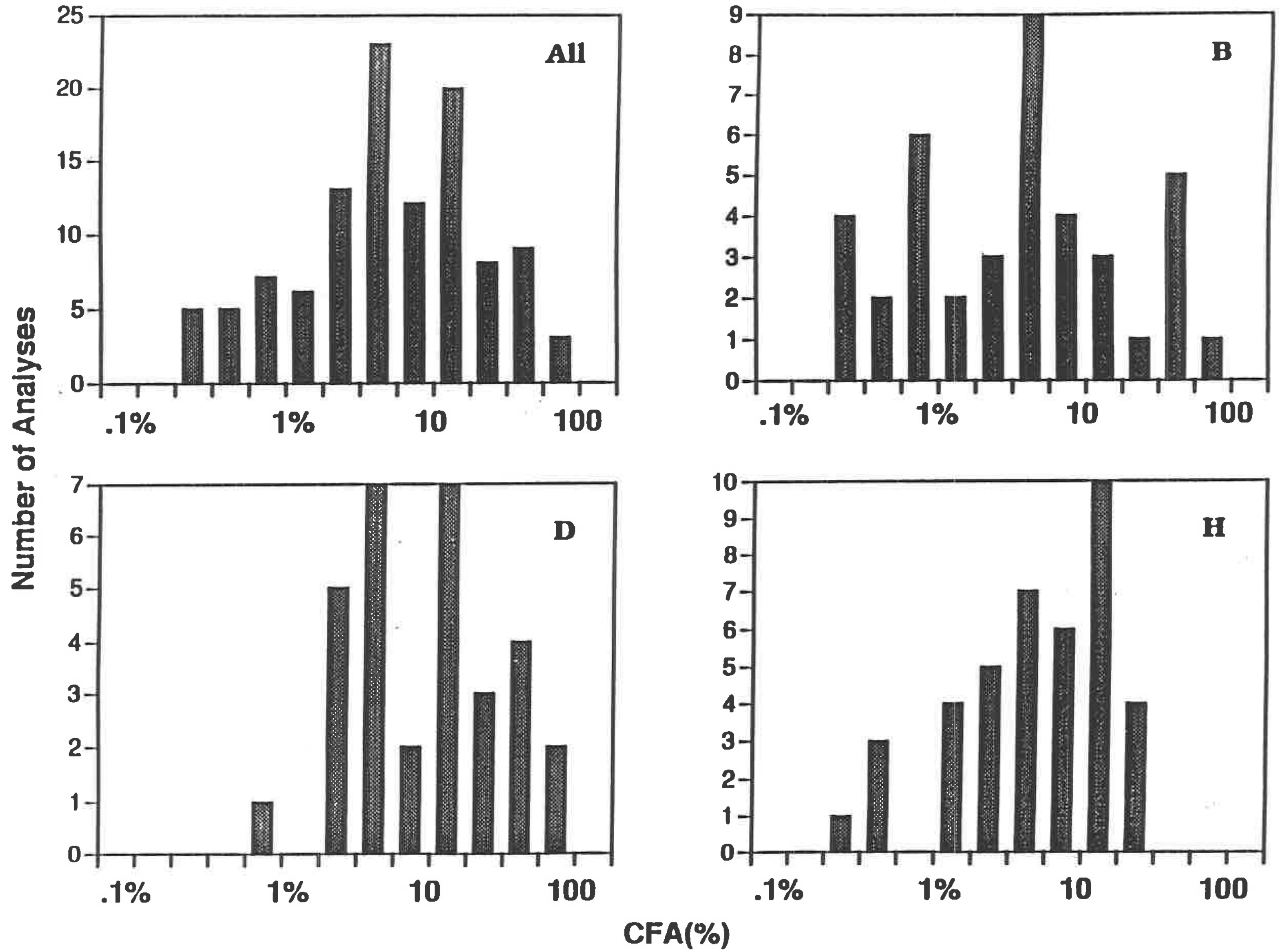
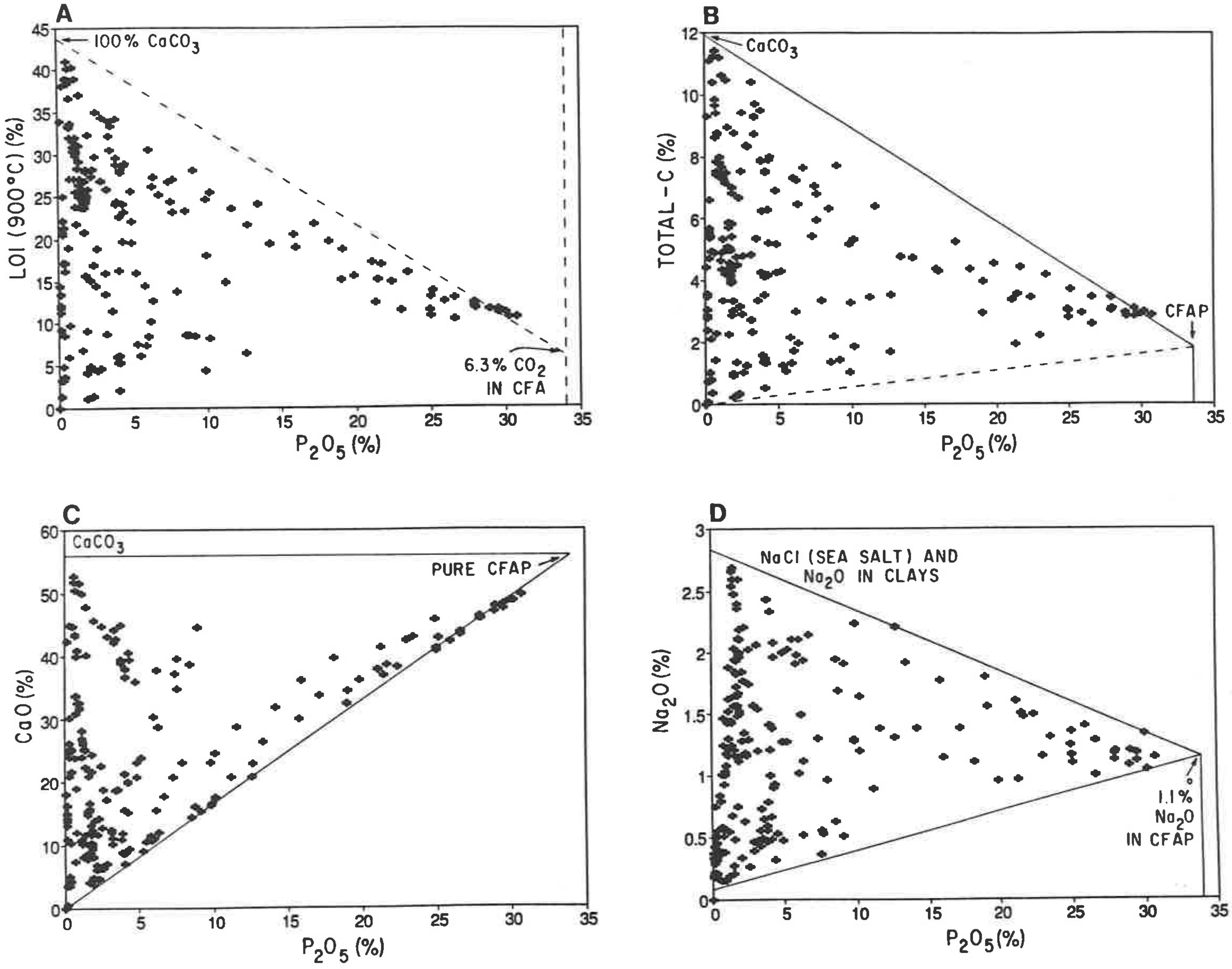


Figure V-2. Plots of major constituents, CaO, LOI, total C, and Na_2O against P_2O_5



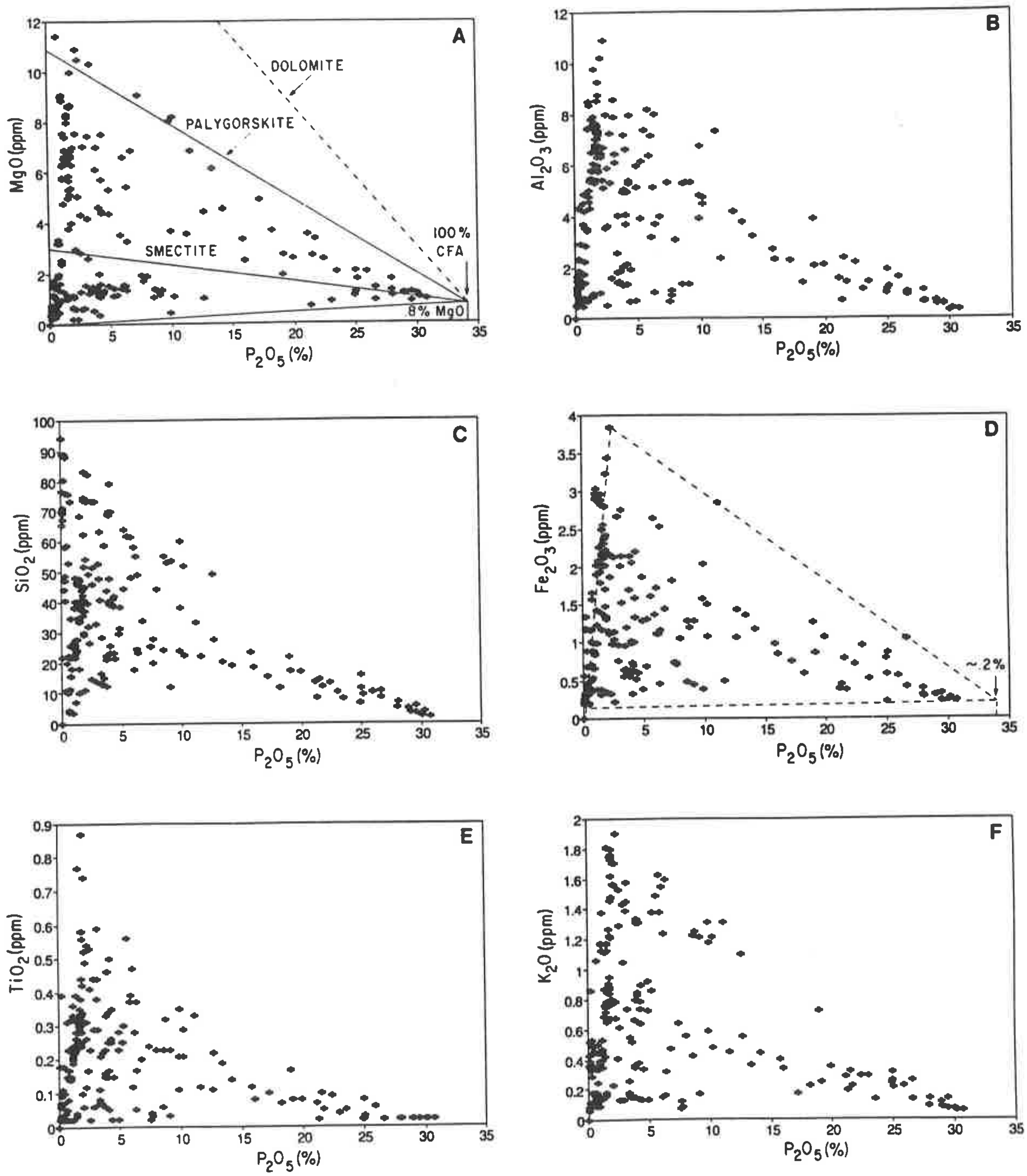


Figure V-3. Plots of major constituents, MgO, SiO_2, $TiO2$, Al_2O_3, Fe_2O_3, and K_2O against P_2O_5.

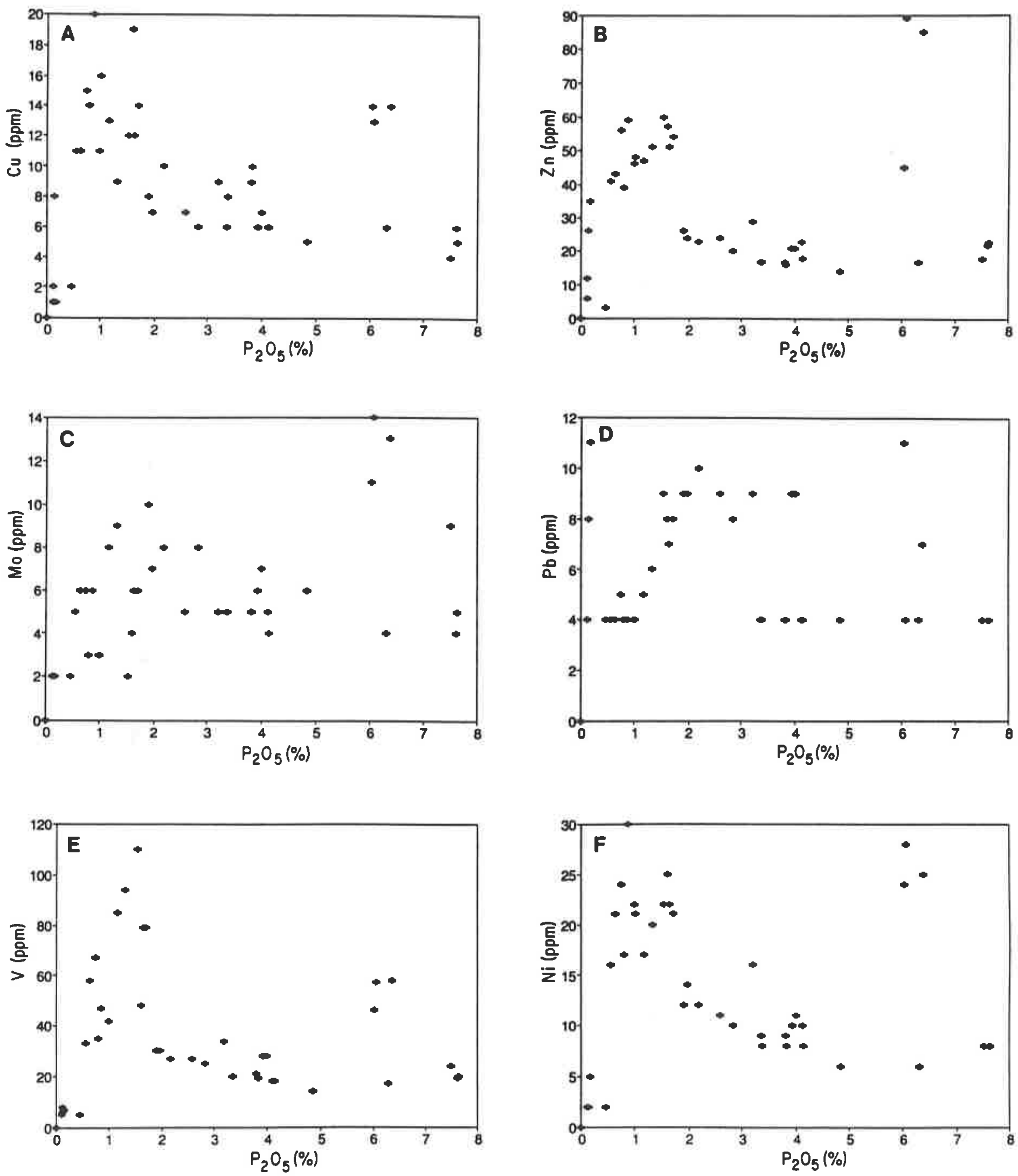


Figure V-4. Plot of trace constituents, Cu, Mo, V, Zn, Pb, Ni against P_2O_5.

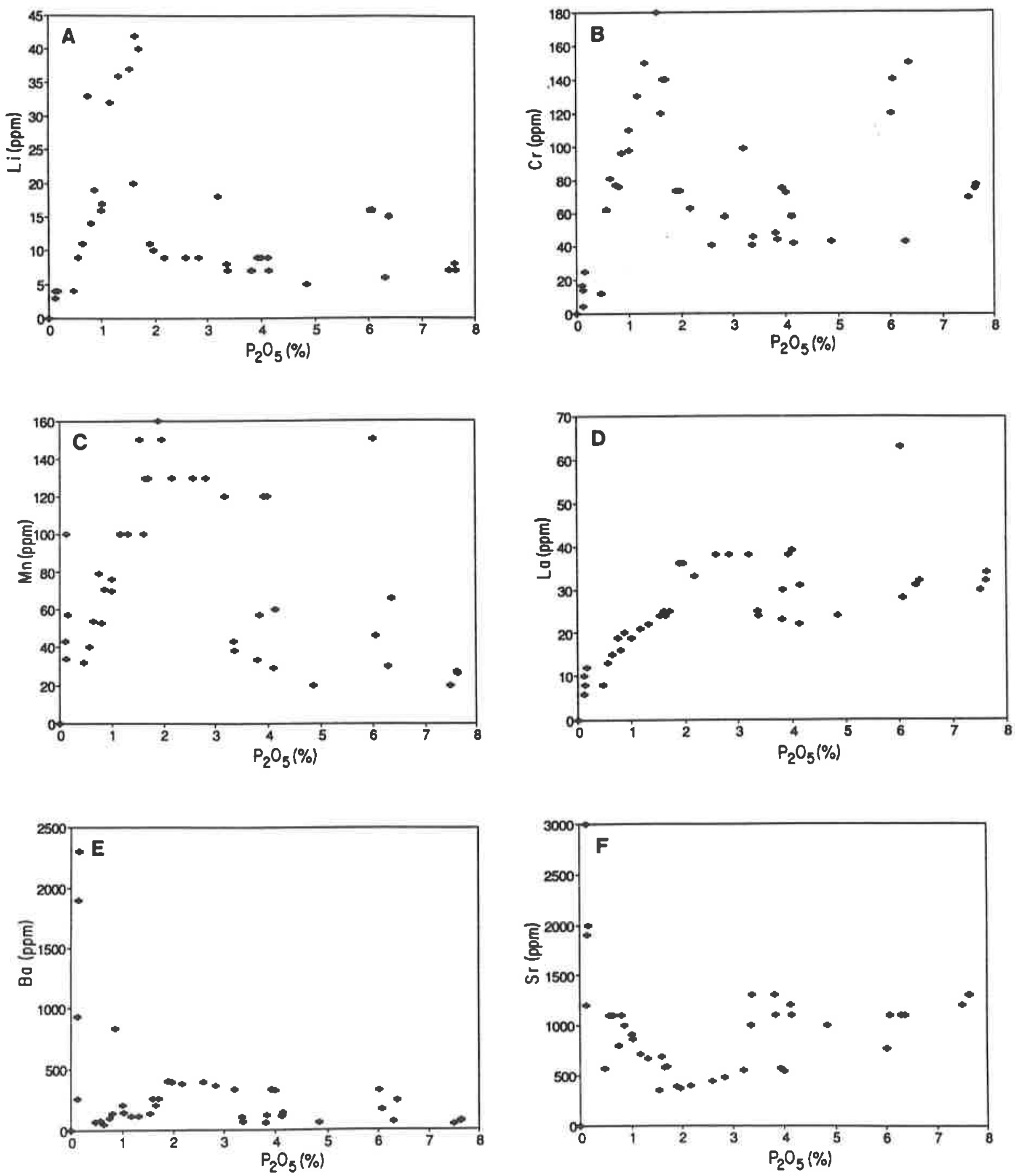


Figure V-5. Plot of trace constituents, Li, Mn, Ba, Cr, La, and Sr against P_2O_5.

Distribution of chemical constituents

Examination of elemental profiles not presented here indicates that the chemical composition of samples is mineral-phase and environment-related, rather than age-related. Rather than discuss chemistry by stratigraphic interval we present here a only brief summary of phosphate distribution and major chemical features and relationships.

The overall distribution of carbonate fluorapatite (CFA), based on chemical analyses , is shown for three sites in Figure V-1. In the individual holes the distribution is multimodal and highly variable, but the histogram of total samples ("All" in Fig. V-1) suggests that with increasing number of cores and samples a lognormal distribution is approached. The median value lies between 4 and 5 percent. This contrasts with a general medians of less than .3 percent CFA, computed from concentrations of phosphorus in a large number of Atlantic Margin sediments (Emelyanov and Romankevich, 1979). Within the Miocene (mainly middle Miocene) (Table V-6). the values appear to average higher, about 16 percent, and values reach a maximum of over 70% CFA in some sections. In general, *even the lowest* phosphate values within the Georgia shelf sections are greater than the *means and medians* for "normal sediments". This supports the concept that the entire middle Tertiary - Pleistocene sedimentary sequence in the continental margin off Georgia is an integral part of a phosphate-enriched province.

Major elements and mineral phases

The major element composition of size-fractionated samples from sites B,D, and H (Table 2) demonstrate the importance of five mineral phases in controlling general sediment composition. These are calcium phosphate (CFA), quartz sand, clay (magnesium-rich, dominated by smectite and palygorskite) and carbonate, mainly calcium, but also some magnesium-enriched carbonates (characteristic sugary dolomite). The compositional relationships between chemistry and mineralogy are drawn largely from previous studies in the general SE U.S. Atlantic margin (Weaver and Beck, 197 MClelland et al, 1989), supported by spot checks by the X-ray powder diffractometry at Woods Hole. Some of the relationships are clarified in Figures V-2 and V-3, which show major constituents plotted against P_2O_5 concentrations for the data set represented in Table 2.

Loss on ignition at 900oC and total C are largely defined by a common constituent, CO_2, and though shown in different units, reveal rather similar point distributions in Figs. V-2a and V-2b. With adjustment for the amount of bound water represented in LOI, the plot extrapolates to excellent agreement with a theoretically-derived structure of carbonate fluorapatite containing about 6.3% CO_2 (McClellan, et al, 1989).

The points in Fig. V-2c are bounded by relatively constant CaO at higher values, because the CaO content of both calcium carbonate and carbonate fluorapatite is similar at 56-58% The plot P_2O_5-Na_2O (Fig. V-2d) extrapolates to a composition of 1.1 % Na_2O in pure marine CFA. At smaller P_2O_5 values than 34.0 % (100% CFA) admixtures of cla ys and other phases contribute Na_2O

bound as NaCl in occluded sea salt and Na_2O in clays or other silicate phases.

Magnesium-rich phases

In Fig. V-3 the role of silicates including clay minerals, is defined in the same kind of plot against P_2O_5. In the range 0-2.5% P_2O_5 we note a dense distribution of points along a high-angle linear trend for MgO, Al_2O_3, Fe_2O_3, TiO2, and K_2O, all elements characteristically present in clays. A similar trend was observed in Fig. 2d for NaO. On the other hand, for SiO_2 the dense distribution stops at about 50% SiO_2 - approaching the limit of SiO_2 in palygorskite, a magnesium-aluminum silicate frequently found in association with phosphate-rich strata (Weaver and Beck, 1977). Although the diagrams do not provide quantitative estimates for the contribution of smectite, palygorskite, and dolomite, one can readily determine from inspection of the distributions that the bulk of the clays cannot be smectite, since pure smectite has only a maximum of about 3% MgO, and up to about 9% MgO is found in samples at the upper end of the steep "clay slope" from 0 to 2.5% P_2O_5. Indeed, the upper limit of points in Fig. V-3a suggest that a mix of palygorskite and apatite could come close to satisfying the range of points at the upper limit of the triangle. However, whereas the clays may contain much palygorskite, the scatter of points in the figures indicate that variable quantities of smectite and dolomite contribute to total magnesium content. By separate chemical computations FTM and JRH arrived at a range of dolomite concentrations up to about 28% in the analyzed samples.

Table V-3d, 3e, and 3f depict Fe, Ti, and K concentrations, respectively. Minimum Fe_2O_3 and TiO2 concentrations in the pellets extrapolate to .2% and .02%, respectively, with maximum sediment concentrations under 4% Fe_2O_3 and about .9% TiO2. Although K_2O appears to partially follow the low-P_2O_5 "clay trend", other evidence suggests that higher levels of K_2O may often be associated with glauconite, rather than smectite. This is to be expected, since glauconite forms in ways quite parallel to phosphate pellet production.

End member phases

Major element compositions of samples conforming most closely to the envisaged endmember phases, CFA, quartz sand, calcium carbonate, and clay, are shown in Table V-5. The approach to the end-member phase is extended toward greater phosphate concentrations by including screened segregations among chemical analyses in the plots. We note in the case of CO_2, Na_2O, and MgO, values of 6.3%, 1.1%, and .8%, respectively, close to values expected for a pure end member CFA (van Kauwenbergh et al, 1990). Fe_2O_3 has minimum values at about .2%, which do not decrease with increasing purity of apatite. These may be associated with coatings and impregnations of Fe_2O_3.

Trace elements

Fewer regularities are found in the trace elements analyzed. However, plots of the trace composition sediments with phosphate less than 10% reveal affinities that are better appreciated by eye than in correlation coefficients or similar statistical indices. In particular, note the sharp increases in values for Cr, Mn, La, Li and other elements in the phosphate range 1-5 percent P_2O_5. This is a range for P_2O_5 typically found in fine grained, especially clayey, sediments that are hosts for pellets regarded by us as primary (Ch. VI). At higher phosphate values trace elements show erratic distributions. We interpret these distributions as generally reflecting clay content. Samples with P_2O_5 values greater than 10-15% are interpreted to have been concentrated by winnowing and selective loss of fines - which would include the clays.

Uranium occupies a specially important place in marine phosphorite pellets, and is almost uniformly enriched where the pellets have not been extensively exposed to oxidizing conditions (such as at a beach zone or in the shallow ground water horizons. Its presence is normally held to be an indicator of anoxic (reducing) conditions at the uptake sites, since U(IV) is much less soluble than U(VI) (Altschuler, 1969). Moreover, the uranium lends the strong signal that phosphorites normally display in gamma logs. The most highly enriched samples of phosphorite pellets (31.1 and 35.1% P_2O_5) both contain 140 ppm of uranium, values quite typical for unweathered marine phosphorites (Altschuler, 1980).

Sulfur is generally higher in phosphate-enriched strata, but does not show increase with phosphate content beyond about 12% P_2O_5. An interpretation of these distributions suggests that a portion of the sulfur is present as sulfate in the CFA lattice, a small portion is present as sulfate in occluded sea water, and a variable quantity is present as iron sulfide. Iron stain and newly-formed gypsum crystals indicate that samples that have been stored for a period of time suffer oxidation of the sulfide with attack on carbonates by bacterially-produced sulfuric acid.

Conclusions:

1) Phosphate, in the form of CFA, is lognormally distributed in the Neogene strata off Georgia if as many as three coreholes are considered. In more limited samplings, phosphate distribution becomes erratic, varying from less than 1% to over 70%. Mean CFA for all samples was about 4.8%, whereas the average value for Miocene strata was about 16% CFA (= 12.2% BPL) Chalcophilic trace metals such as copper, zinc, cadmium, lead, and to some extent, arsenic, and molybdenum, are not specifically associated with the apatite structures, but may be better correlated with fine, clayey, and organic-rich sediments that may be partially associated with primary apatite pellets.

3) The distributions of ignition loss (CO_2 liberation), CaO, and direct determination of total carbonate agree with a theoretical apatite model having P_2O_5 concentrations of about 34.0% P_2O_5 and close to 6 % lattice-bound CO_2.

4) Uranium reaches values of 140 ppm or ug/g in the phosphate-rich strata and is clearly the source of high gamma ray counts in geophysical logs.

5) The dominant clay phase appears to be palygorskite with subsidiary smectite. The dominant potassium-bearing phase may be glauconite

6)The approximate composition of an extrapolated pure CFA phase in the TACTS area is SiO_2 1.5.%, Al_2O_3 .2%, CaO 56%, Fe_2O_3 .2%, MgO.9%, P_2O_5 34.0%, CO_2 6.3%.

7) The phosphorite pellets that characterize the TACTs cores are classical marine phosphorites in the chemical makeup, and are distinguished from phosphates leached in the ground water zone by higher MgO (0.9% in the pure phase), U, and relatively high lattice-bound CO_2 (6.0%).

VI REGIONAL SUMMARY OF THE GEOLOGY OF THE MIOCENE OF GEORGIA AND OBSERVATIONS FROM THE SEISMIC REFLECTION PROFILES AND THE TACTS CORES

By P. Popenoe, P. F. Huddlestun, and J. V. Henry

Introduction

The Continental Shelf and Slope off Georgia are covered by a relatively extensive network of high-resolution seismic-reflection surveys (Fig. VI-1) collected during the period 1977 to 1981 by the U.S. Geological Survey and by the University of Georgia. The data were collected for, and were partly funded by, the Environmental Studies Program of the U.S. Bureau of Land Management (under functions later assumed by the Minerals Management Service) prior to OCS Lease Sales 43 and 56, when information was needed on the geologic hazards and constraints to petroleum exploration and development activities on the Outer Continental Shelf.

Although seismic stratigraphic analyses were made in the past of this data set (Edsall, 1978; Paull and Dillon, 1980), the previous analyses were hampered by a lack of stratigraphic ties to offshore wells with modern foraminiferal biostratigraphy. The GILLISS data set acquired in 1979 (Figure VI-1) also was not available for the previous analyses. Because of this, only generalized stratigraphic analyses were possible in the past. The TACTS cores now provide a biostratigraphic and lithostrtigraphic framework on which we have based a more detailed stratigraphic analyses, which includes maps of the thickness and extent of the early, middle, and late Miocene and Pliocene units and their depths across the shelf (Popenoe, 1991). The core descriptions also provide information on lithology that can be used to imply environment of deposition. These detailed analyses of the cores in combination with the seismic data set form the basis for the following discussion, which provides interpretations and syntheses of the seismic stratigraphic maps and cross sections reported in Popenoe (1991).

In this report we have limited our discussion to the Miocene, Pliocene, and Quaternary sediments, as these are sediments that are of potential commercial interest. The Miocene sediments of southeastern Georgia record five major sea level rises across the Continental Shelf, as well as a number of lesser sea-level fluctuations. An additional sea-level rise and fall is indicated for the Pliocene (Figure VI-2). The rises and falls of sea level are recognized in our seismic-reflection records by depositional sequences of relatively conformable strata that are separated by intervening unconformities. These sequences are generally believed to be deposited during the sea level rise which creates space below the wave base (accommodation space) in which deposition can occur. The seismic stratigraphic units identified and traced by our study correlate with stratigraphic sequences identified in the TACTS cores or with geologic formations identified on the Coastal Plain. The unconformities between these units mark the falls in sea-level where much of the materials deposited during the sea-level rise on the Coastal Plain or inner to middle shelf is removed by erosion and transferred offshore, eventually to end up on the slope or upper Continental Rise.

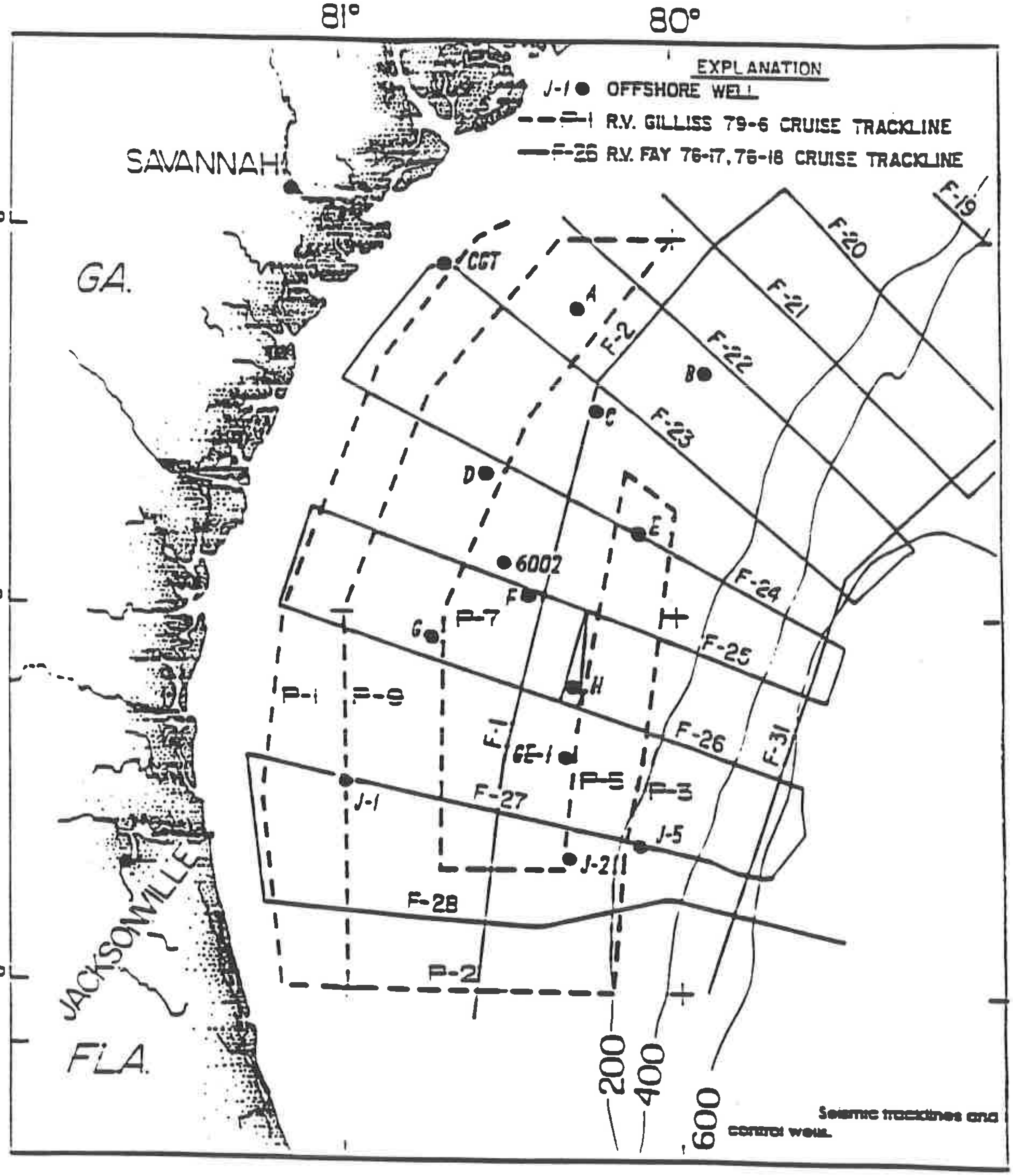
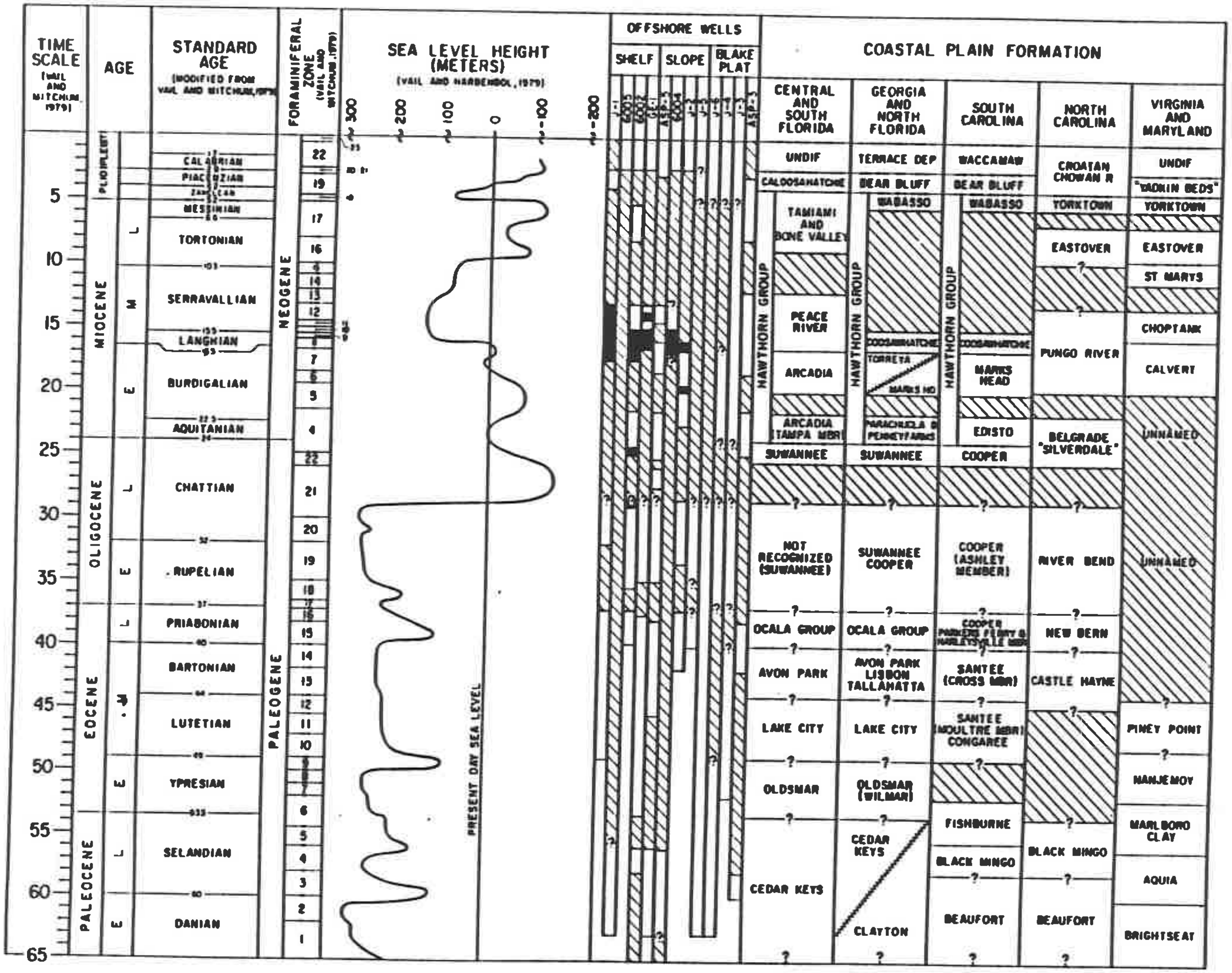


Fig. VI-1. Tracklines of USGS seismic-reflection profiles collected under the joint USGS and BLM Environmental Studies program. For University of Georgia/USGS tracklines and seismic data see Henry and Kellam (1988).

Figure VI-2. Correlation chart and sea level curve for southeastern U.S. Coastal Plain formations (From Popenoe, 1990)



The unconformities that we have mapped are extremely complex features. In many cases high stands of sea level recognized by rugged unconformities cut by the Gulf Stream scour on the outer shelf and slope can be traced landward into unconformities that contain fluvial and tidal barrier channel systems that indicate low stands of sea level. In most cases the regressive or offlap sequences of strata seem to be absent, and the unconformities are overlain by onlapping beds. It is common for several unconformities to merge into a single surface that has been resistant to erosion through a number of eustatic cycles. In some cases unconformities truncate underlying strata, whereas in other cases a disconformity that may represent a gap 20 million years or more is identified on the seismic records only by a stronger reflection. The major phosphorite enrichment zones appear to occur along both major and minor unconformities, highlighting these features as *the enrichment* phase of phosphogenesis, whereas *primary* deposition of phosphate is believed to take place during high sea-level stands (transgressions) (Manheim and Herring, Chapter V).

The deposition of Miocene strata in eastern Georgia and across the Continental Shelf was into a broad basin (the Waycross Basin of Figure VI-3), as well as across higher areas of the adjoining shelf and Coastal Plain. This basin was occupied by a huge embayment during the early and middle Miocene that extended into central Georgia and across the entire present shoreline of the State (Figure VI-4). The basin caused Miocene deposition in Georgia to be generally under deeper-water conditions than deposition of equivalent-aged strata on the shelf off North and South Carolina or northern Florida where basins were generally not present (for a more complete discussion see Popenoe, 1990). During highest sea-levels of the Miocene, the entire Coastal Plain of Georgia was probably inundated, and a shallow seaway existed between the Gulf of Mexico and the Atlantic (Fig. VI-5). The deepest part of the basin under the Continental Shelf lies west of Borehole G and north of JOIDES 1, where the basin has nearly 80 m of relief relative to its northern edge near the mouth of the Savannah River (Figure VI-3). By the close of the Miocene the Waycross basin had been nearly filled by deltaic and pro-deltaic deposits inland in southeastern Georgia. These poorly-sorted sands and clays grade eastward to shallow-water marine phosphatic clays and sands near the present shoreline and offshore. The Miocene ended with a major sea-level regression that exposed the shelf and Coastal Plain to subaerial processes. In the offshore, Pliocene sediments were deposited chiefly into a broad valley cut during the subaerial exposure of the inner shelf during the late Miocene (Inner Shelf Low of Fig. VI-6).

Miocene sediments, their seismic character, and distribution

<u>Aquitanian (Early Miocene)</u>
Boreholes A,B,D, and F, as well as AMCOR 6002 and GAT 90 penetrated Aquitanian-age sediments equivalent to the lower Parachucla of onshore Georgia and the Edisto Formation of South Carolina. These marine sands, clays, calcites and dolomites underlie most of the Southeast Georgia Embayment and extend as far west as the Pelham Escarpment, a cuesta that extends from the vicinity of Wilcox, Georgia, southwestward to southern Decatur County, Georgia (Huddlestun, 1988).

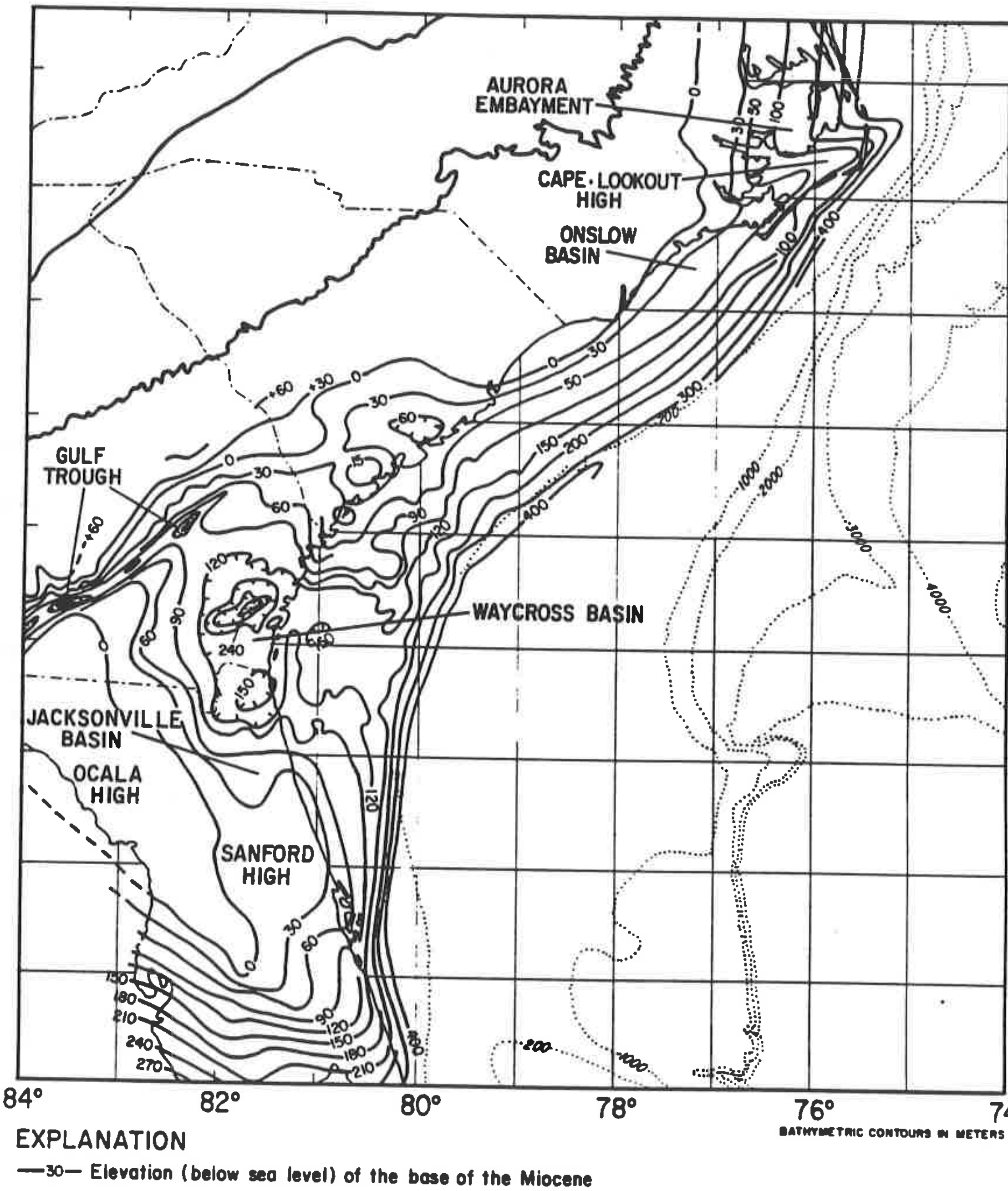


Figure VI-3. Map of depth to base of Miocene for the Southeast Georgia Embayment (From Popenoe, 1991). UCCGLT-SV refers to the Savannah Light corehole.

Figure VI-4. Paleogeographic reconstruction of the southeastern Atlantic margin early Burdigalian time (from Popenoe, 1990).

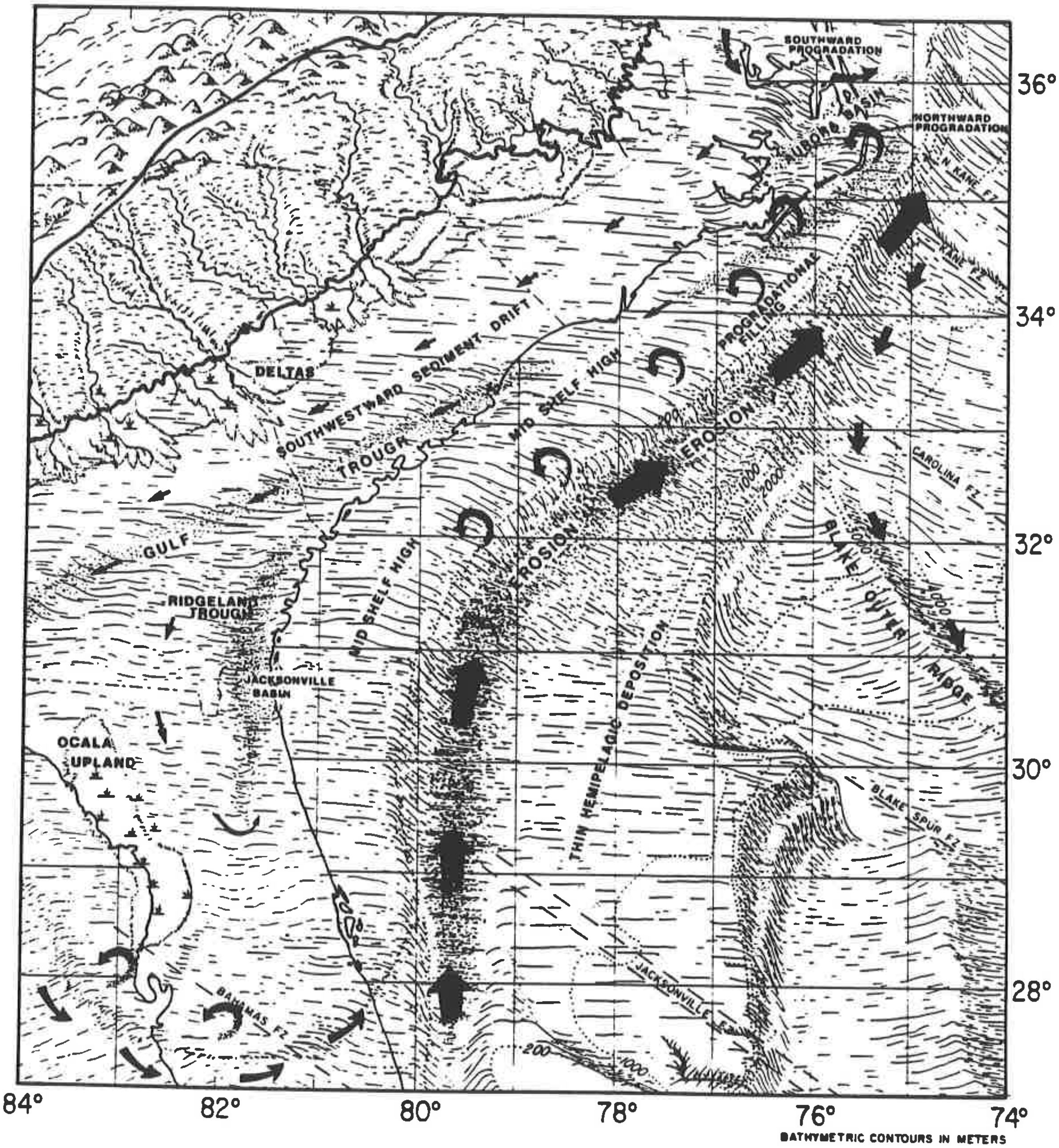


Figure VI-5. Paleogeographic reconstruction of the southeastern Atlantic margin in Middle Miocene time, during maximum sea level height (from Popenoe, 1990).

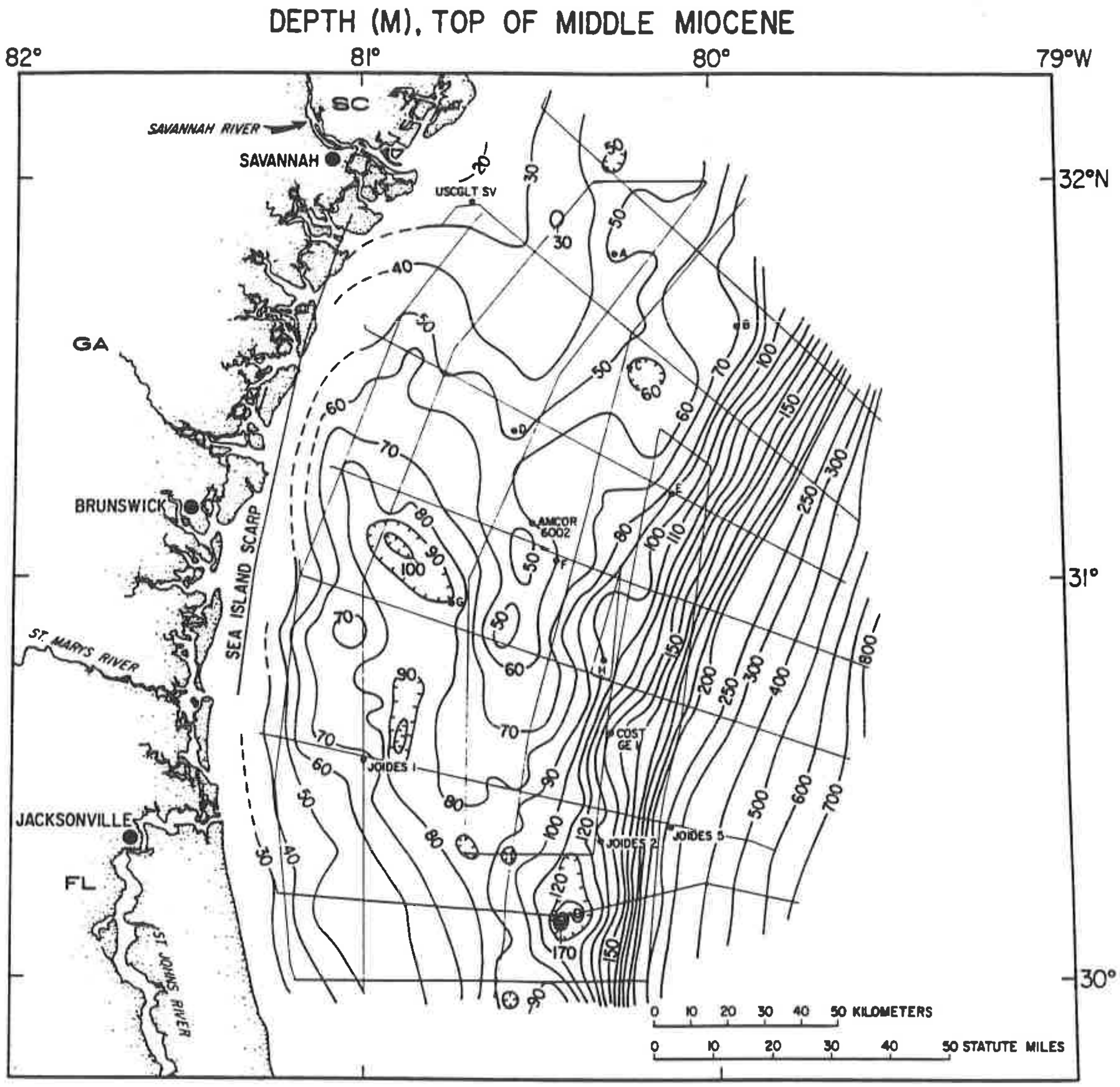


Figure VI-6. Depth to the top of the Middle Miocene (from Popenoe, 1991).

Huddlestun (1988) equates the offshore Aquitanian age sediments to the Cooper Formation, since their lithology (rather than age or correlation) is similar to the late Eocene and Oligocene age Cooper Formation of eastern South Carolina. The offshore unit is more dolomitic than the typical Parachucla Formation onshore. Under the shelf, the Aquitanian sediments consist of olive silty clay and brownish-olive sandy calcarenite, deposited in a shallow marine environment.

On the seismic records Aquitanian age strata appear as parallel-layered or banded reflectors that are not readily discernable from the overlying Burdigalian-age beds. The unit is bounded at its base by a strong reflector that marks a major unconformity on the top of the Oligocene age sediments and a change in both composition and compaction. The top of the Aquitanian-age beds is only a minor reflector, indicative of a disconformity or paraconformity, making it difficult to follow or to separate from Burdigalian-age strata. The unit is variable in thickness, but rarely exceeds 20 m. It is thickest in the broad closed depression that underlies the inner shelf (the hachured contour area west of Borehole G on Fig. VI-6) and thins or pinches out to the north and south into the high at the mouth of the Savannah River and over the Florida Platform off Jacksonville, Fl., as well as offshore toward the shelf edge. The absence of the unit in Borehole C is due to this seaward pinchout of the unit.

Aquitanian-age sediments are relatively poor in phosphorite content but contain thin zones of up to 10% phosphorite where penetrated by the TACTS cores. Enriched phosphorite zones occur at the upper boundary in Borehole D, and at GAT (Tybee Island) 90, marked by to concentration of phosphatic pebbles and sharks' teeth. However, available samples near the unconformity are not highly phosphatic in Boreholes A, B, and F. Insufficient samples are available to determine its nature at the Savannah Light Tower site. Aquitanian age sediments are generally poorer in phosphorite than the overlying Burdigalian or middle Miocene units in the central-northern Georgia area, both onshore and offshore.

<u>Burdigalian (middle and upper early Miocene)</u>
Burdigalian age sediments were penetrated in the JOIDES-1, JOIDES-2, Boreholes A,D, E, F, G, and in GAT 90. These sands, clays and calcarenites are equivalent to the onshore Marks Head Formation of eastern Georgia (Huddlestun, 1988), deposited in an estuarine or restricted marine environment. Southward, in the Savannah, Georgia area, the Burdigalian age beds were deposited in a more open marine, shallow water environment. The unit grades westward in Georgia into fine-to coarse-grained sands with scattered beds of pebbles deposited as shallow-water deltas (Torreya Formation).

On seismic records Burdigalian-age sediments in the offshore have the banded or parallel-layered appearance that is typical of all Middle- and Early Miocene-age beds (Figure VI-8). The disconformity or paraconformity that marks their top is more strongly developed than that at their base (Aquitanian top) and in many cases occurs along a change of lithology from clay (parallel banding), to sand (more discontinuous, poorly banded). On the

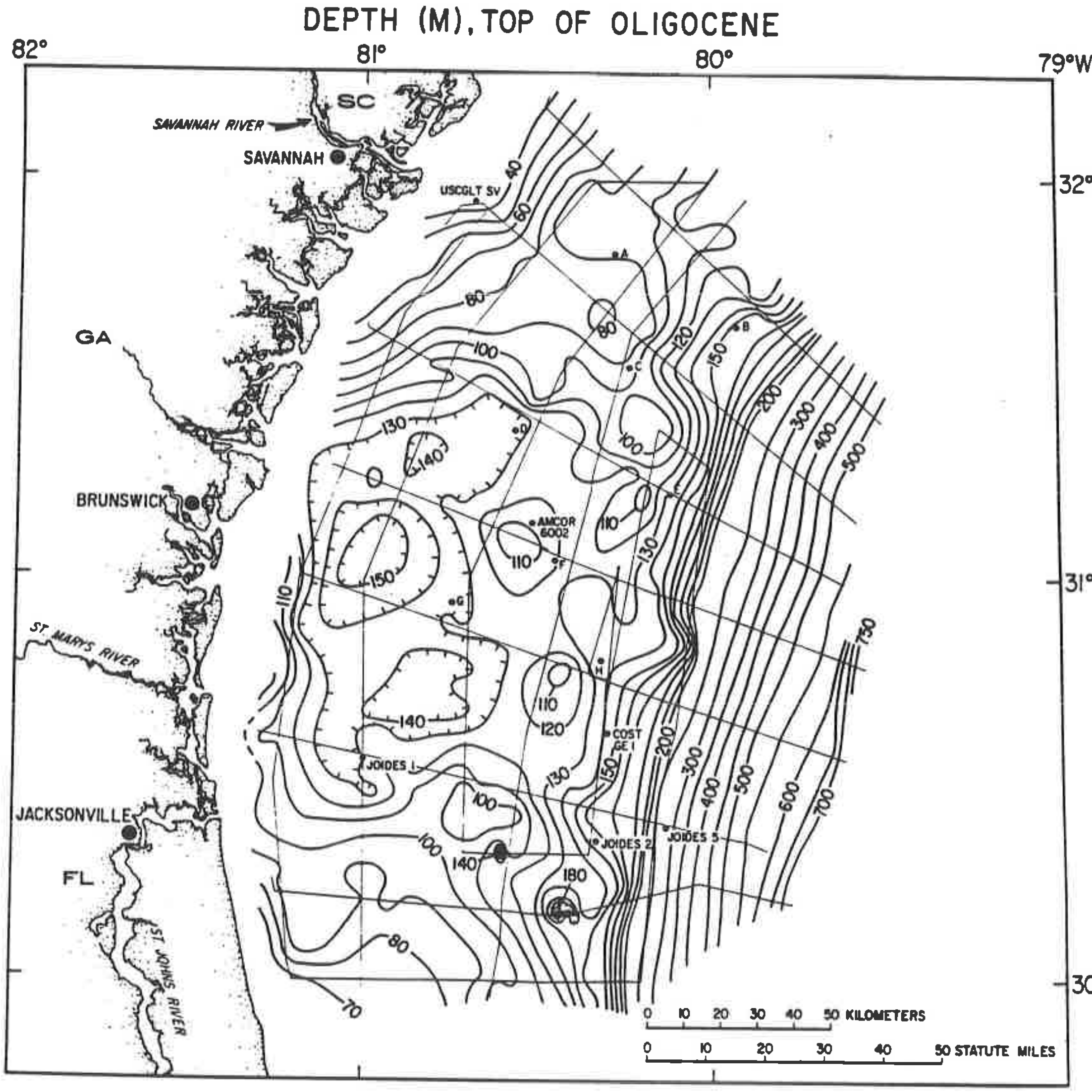


Figure VI-7. Depth to the top of the Oligocene or equivalent unconformity (from Popenoe, 1991).

middle shelf the top of the unit is an unconformity that shows extensive erosional relief of more than 10 m, and broad areas where distinct layers have been discontinuously stripped from the top of the unit. Both borehole and seismic stratigraphic data indicate that Burdigalian-age strata are generally under 15 m thick, and, like Aquitanian-age strata, are discontinuous in the subsurface. The beds are thickest in the central basinal area of the shelf near Borehole G (Figure VI-7), and thin both seaward to where they pinch out under the outer shelf, and northward and southward on the margins of the basin.

The Burdigalian section drilled in Boreholes A, GAT 90, and in J-1 and 2 have zones with up to 20% phosphorite. Burdigalian age beds within the Pungo River Formation of North Carolina are mined for phosphorite at the Lee Creek Mine in the Aurora Basin. Riggs and others (1985) report that these same strata off North Carolina in Onslow Bay contain beds that contain up to 40% phosphorite. In both Borehole D and in the Onslow Bay deposits, the richest Burdigalian phosphorite beds occur just above the basal unconformity that separates the two major Lower Miocene units, the Aquitanian and Burdigalian, indicating that this enrichment is probably due to reworking and enrichment of phosphorite through winnowing of fines at the unconformity. Although the exact location of the Aquitanian-Burdigalian unconformity has not been published for J-2, it probably is at 350 ft where there is a phosphorite enrichment of 30%. The sea-level fall at the close of the Burdigalian (Haq and others, 1987) is expressed as a major unconformity across much of the Continental Shelf.

<u>Langhian (Early Middle Miocene)</u>

Langhian seas are believed to have reached levels of over 250 m above the present (Haq et al, 1987) and at one time probably covered the entire area of peninsular Florida (Scott, 1990), as well as coastal Georgia and the Carolinas. They are found now only in isolated outliers in Florida, which indicate part of their former extent (Scott, 1990) and are poorly preserved in Georgia and offshore, perhaps because the sea-level lowering at the close of the Langhian to 50 m above present levels removed or reworked most of these sediments.

Langhian sediments (lower Middle Miocene) are absent or have not been identified in the TACTS cores, but sediments of Langhian age were identified in JOIDES 1, 2, and 5, and in GE-1 off Georgia (Poag and Hall, 1979; Popenoe, 1990). At the GE-1 well, Langhian sediments consist of a coquina of brecciated, water-worn shells and oolites with phosphatic pebbles, quartz sand, limestone and dolomite suggestive of shallow-water, high-energy conditions, as would be found on an offshore shoal (Rhodehamel, 1979; Huddlestun, 1988). Our seismic data suggest that this coquina unit forms a residuum along an erosional unconformity that represents the Langhian to Oligocene interval at the GE-1 well, thus the coquina recovered at the well is not representative of the unit, but is probably a residuum of shells at the upper Oligocene to Middle Miocene unconformity that is present at the well.

The GE-1 well was logged from cuttings, and our new interpretation indicates that some of the stratigraphic picks in the well may have been affected by

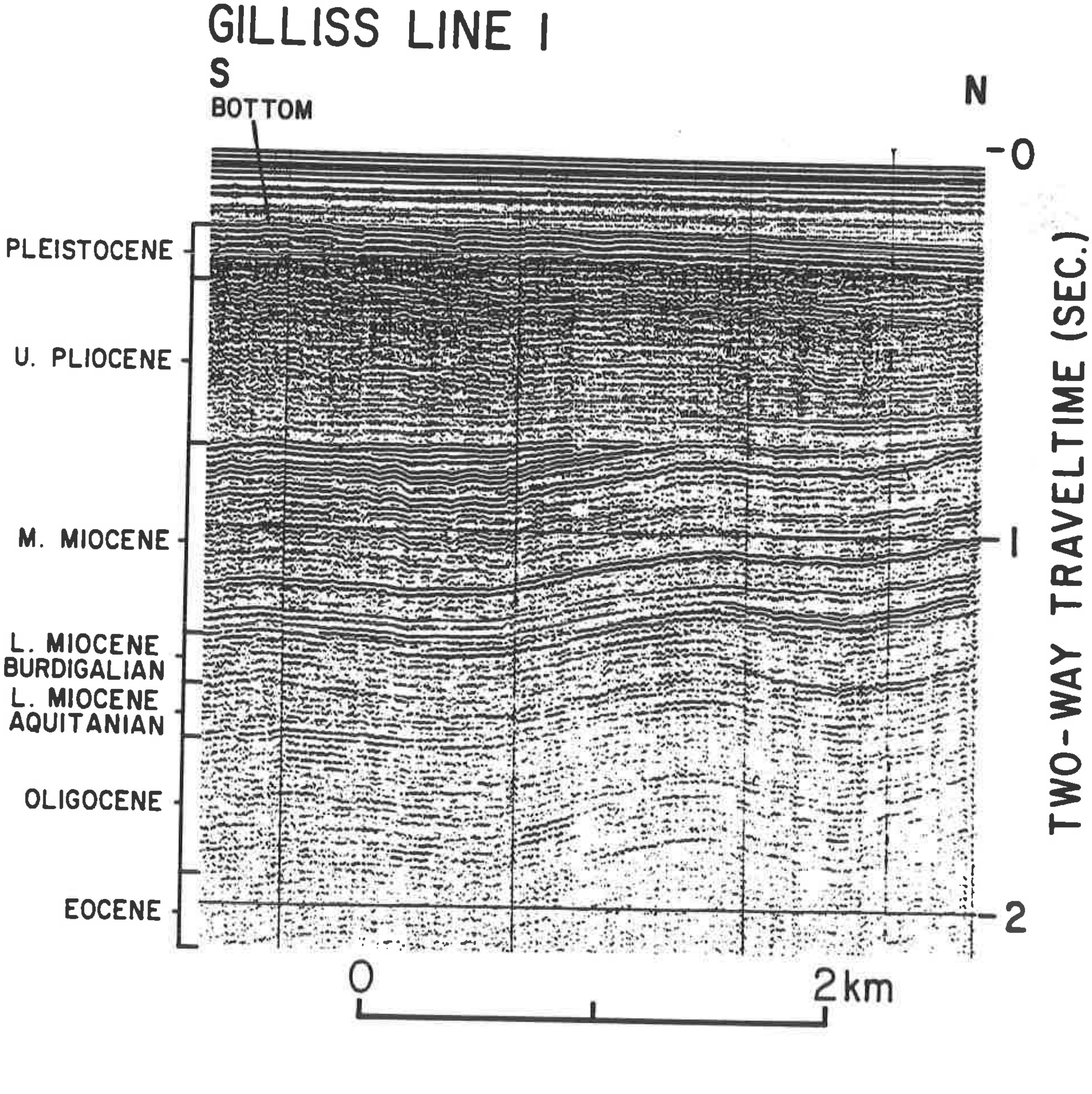


Figure VI-8. Seismic record showing the typical parallel layering or banded appearance of Miocene strata on the inner shelf.

cavings from shallower beds. The seismic stratigraphic data clearly show that the interval logged as middle Miocene (Langhian) at the GE-1 well correlates with a complex unconformity that overlies strata identified as Oligocene in age in JOIDES 2. This interval also lies below the middle Miocene (Serravallian) unit in Borehole H, which can be traced with little room for doubt into strata identified as Pliocene in the GE-1 well. We therefore suggest that the GE-1 well picks are wrong in the Miocene-Pliocene interval and have relied on paleontologic picks in Joides 2 and Borehole H in compiling our maps.

Off North Carolina, in Onslow Bay, the Langhian-age sediments consist of clean quartz sands interbedded with muds deposited in an outer-shelf to upper-slope environment (Katrosh and Snyder, 1982). The sediments are phosphatic but at present have not been identified as containing a minable resource. In Florida, however, the unit forms the lower part of the Peace River Formation (Scott, 1985), which contains quartz sand beds having greater than 50% phosphorite.

<u>Lower Serravallian (middle Miocene)</u>

A thick and phosphatic lower Serravallian age sequence of carbonate muds, clays, and argillaceous sands was cored at TACTS Boreholes B, C, D, E, G, and H, and at AMCOR 6002 and Tybee Island Borehole (GAT 90). Upper Serravallian-age strata appear to be absent over much of the shelf but have been identified in AMCOR 6002 (discussed later). Seismic stratigraphic data show that Lower Serravallian age sediments are the major unit in the shallow subsurface of the shelf, having a volume perhaps five times that of the Lower Miocene and producing a major outbuilding at the shelf edge. Serravallian age rocks underlie and crop out on the slope between a depth of about 230 m to near the base of the slope at over 500 m.

Over the slope the outcrop area of the Serravallian-age sediments is easily recognized on bathymetric profiles by a rough bottom caused by both phosphorite pavement at the sea floor and by deep-water "coral mounds" (Stetson et al, 1956; Ayers and Pilkey, 1981). Under the shelf the Serravallian-age sediments are easily identified on seismic-reflection records from the inner shelf by their strong, continuous layering, or banding, which reflects both the alternation of sand and clay layers as well as at least three stratal disconformities (Figure VI-8). The stratal disconformities can be traced around the seismic network into minor unconformities. On the outer shelf they are less easily traced because the unit is more seismically transparent, suggesting a sandy character. Serravallian strata are bounded at their base by the unconformity that marks the top of the Burdigalian-age strata, and in some areas by a merged unconformity that spans the Oligocene to Middle Miocene (the COST GE-1 well). At their top they terminate in a major unconformity that marks a rugged erosion surface of upper Miocene (Tortonian-Messinian) age.

The offshore Serravallian age strata are equivalent to the onshore phosphatic Berryville Clay Member and the Tybee Member of the Coosawhatchie Formation (Huddlestun, 1988) of eastern Georgia. They grade westward into a more clastic and non-phosphatic facies (Ebenezer Member). In onshore Georgia these beds represent deltaic-lacustrine, littoral and neritic environments (terrigenous to middle-shelf marine) (Abbott, 1974). On the Continental Shelf, the section drilled by the TACTS cores is a deeper-water, outer-shelf to upper-slope facies containing mainly planktonic foraminifera (Huddlestun, personal communication 1988).

Serravallian age strata are the most phosphatic sediments in the northern TACTS cores. The unit is dominantly a marine clay but contains sand and silt layers (Boreholes B, D, J-1, AMCOR 6002, GAT 90,), that contain more than 50% phosphorite pellets. Seismic reflection line GILLISS 7-P (Fig. VI-1) passes near both Borehole D and AMCOR 6002. Although the lithologies of the phosphatic zone are different in the two wells (sand in Borehole D, and clay in 6002), seismic data indicate that the phosphatic layer lies along the same minor unconformity.

The Coosawhatchie Formation of Georgia is equivalent to the upper part of the phosphatic Peace River Formation of Florida and the upper Pungo River Formation of North Carolina. In Onslow Bay, Riggs and others (1985) have suggested that this unit probably represents a minable resource, constituting their BBF-1 to BBF-8 units. BBF-1 lies on the Langhian-Serravallian unconformity and contains phosphorite layers as rich as "75%"

The Upper Miocene unconformity

A pronounced major unconformity representing the upper Miocene (lower Tortonian) truncates and deeply incises the top of the Middle Miocene strata under the shelf and has removed Middle Miocene strata entirely in some areas. As shown in seismic profiles by Kellam and Henry (1986), and our USGS profiles, a wide (>50 km) and deep(>40 m) channel (inner-shelf low, Figure VII) has been cut on the inner shelf bounded to the west by a buried escarpment called the Sea Island Escarpment (Kellam and Henry, 1986; Huddlestun, 1988) and to the east by the mid-shelf high. The channel bends offshore, intersecting the shelf edge off northern Florida. The channel can be traced northward and westward into the area of the Savannah and Altamaha Rivers, leaving little doubt that it was cut by fluvial erosion associated with these river systems during subaerial exposure of the shelf during Late Miocene time. Because Late Miocene age sediments infill this feature, the erosion can be dated to the Tortonian and the Messinian.

Other evidence that indicates subaerial exposure of the entire shelf during the late Miocene is the development of sinkholes and karst features along the Tortonian unconformity. It is obvious that the Tortonian-Messinian unconformity represents the primary time of extensive subsurface dissolution of the deeper limestones under the shelf, since most sinkhole collapse depressions and dissolution features, which have visibly warped the subsurface Miocene, Oligocene, and Eocene strata, terminate abruptly at the unconformity (Figure VI-9). Subsidence of a broad area underlying the inner-shelf low has also contributed to the relief of this channel relative to the mid-shelf high and large sinkhole-like features that lie within the channel off northern Florida.

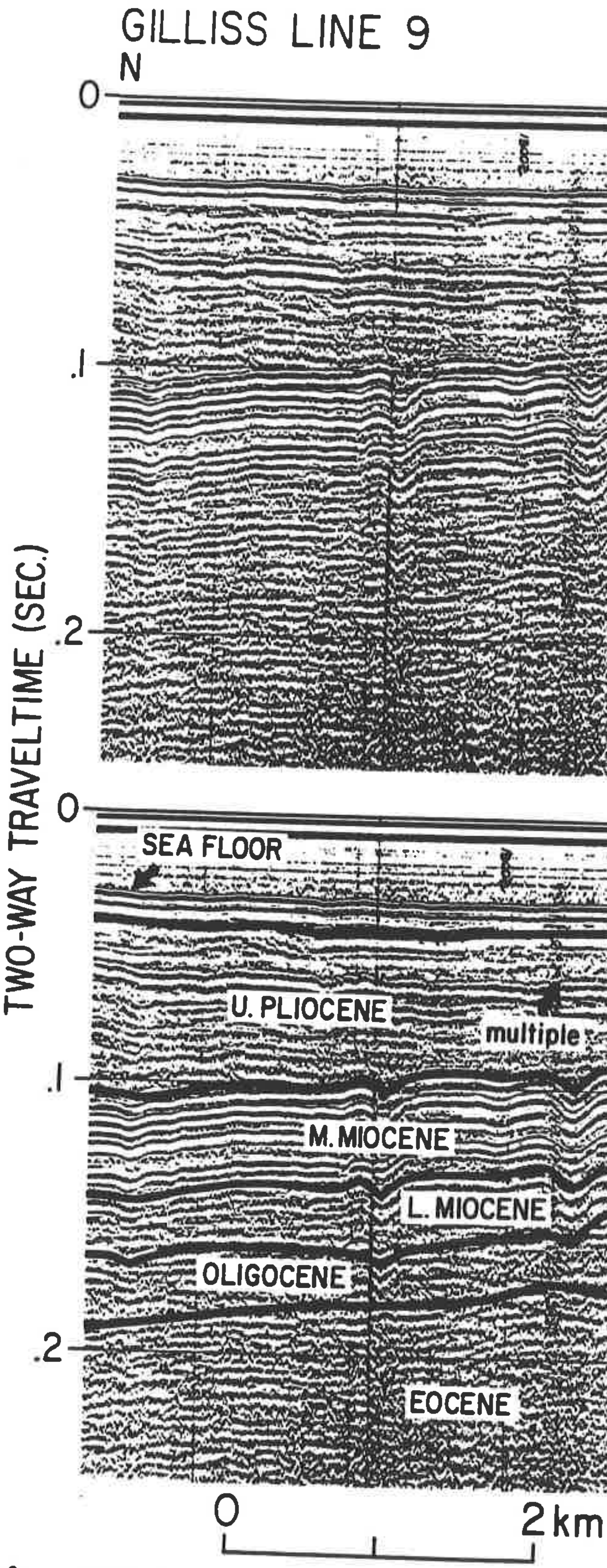


Figure VI-9. Seismic profile showing evidence of dissolution features originating in the Oligocene that have warped the overlying Miocene strata on the inner shelf.

Borehole G is the only TACTS core that lies within the inner-shelf low, while Boreholes D, F, and AMCOR 6002 lie along the mid-shelf high. The inner-shelf low is now filled with a thick, prograding section of upper Miocene (Late Tortonian), and lower and upper Pliocene-age sands. The relationship of the upper Tortonian age sediments in AMCOR 6002, which constitute a channel-fill sequence, constrain the age of the first major erosion of the channel to the Early Tortonian. The channel appears to have been active again in the Messinian when deposits of late Tortonian age were partly stripped away before deposition of the Early Pliocene and late Pliocene age units. Kellam and Henry (1986) suggest that winnowing and concentration of phosphatic material could have occurred along the Tortonian unconformity, concentrating phosphorite in stream channels and topographic lows. They have also suggested that erosional holes observed in seismic profiles southeast of the Savannah Light Tower at the apex of a regional high on the Miocene top, that occurs directly off the mouth of the river system, would be primary exploration targets. From all available evidence, the authors of this chapter agree with that observation.

Evidence for enrichment of phosphorite along the upper Miocene unconformity is provided by the sand layer with over 70% phosphorite at the upper Miocene unconformity at Borehole B. Reworked residual phosphorites at the unconformity are probably responsible for the enrichment. Similarly, much of the phosphorite enrichment at the Savannah Light Tower hole is probably due to enrichment at the upper Miocene unconformity.

The phosphorite zone penetrated at 6002 is truncated by the upper Miocene unconformity along seismic line GILLISS-7 about 4 miles south of the hole. This is another area where sediments could have been reworked and possibly enriched along the unconformity. Alternatively, the phosphorite may have been completely eroded away along the unconformity in this area.

Tortonian-Messinian (upper Miocene)

Over most of Georgia the upper Miocene is expressed as an erosional hiatus. Well 6002 off Georgia cored 10 m of olive silty clay topped by dark, grayish-brown phosphatic sand containing late Serravallian and late Miocene diatoms (Abbott, in Hathaway and others, 1979). C.W. Poag (personal comm., 1986) identified N-17 foraminifera (late Tortonian-Messinian) (Kennett and Spinivasan, 1983) in these same sediments, suggesting that the unit is equivalent in age to part of the phosphatic Peace River and Bone Valley Formations of central Florida. The upper Miocene unit occurs mainly on the west flank of the mid-shelf high (Kellam and Henry, 1986, Popenoe, 1986) and is an erosional remnant of a more extensive blanket of late Miocene sediments that once covered most of southern Georgia and Florida before being removed by subaerial erosion in the latest Miocene (Messinian) low sea-level stand. The environment of deposition of the AMCOR 6002 sediments was open-marine, Continental Shelf (Huddlestun, 1988).

The Upper Miocene unit appears on seismic records as transparent in signature, similar to the Pliocene beds, from which it cannot be distinguished. Similarly, in lithology, it resembles the "Wabasso Beds" of lower Pliocene age (discussed below). The unit in 6002 helps to date the major late Miocene erosion under the shelf, since the unit in AMCOR 6002 progrades by sigmoid offlap from the mid-shelf high into the inner-shelf low.

The late Miocene strata under the Georgia shelf do not appear to be notably phosphorite-rich from the available well data, however since the sediments were derived in large part from erosion of middle Miocene age strata, it should not be discounted as having possible commercial phosphorite value.

Pliocene sediments, their distribution and character

Lower Pliocene (Zanclean)

TACTS boreholes A, D, F, G, and H penetrated phosphatic sand, silty sand, silt, and silty clay of lower Pliocene (Zanclean) age. This unit is known only from coastal Georgia onshore, having been penetrated in Chattam County under Tybee Island and named the Wabasso beds by Huddlestun (1988). Beds of this age are apparently thick and widespread in eastern Florida (Cypresshead and Nashua Formations; Scott, 1990), but are poorly known in Georgia and are known from well data only as far north as Beaufort, South Carolina (Huddlestun, 1988). The sections penetrated by the TACTS cores represent the thickest sections known in the Georgia area (>50 m in Borehole G). Huddlestun states that the abundance of planktonic foraminifera and the relatively high diversity of the benthic foraminifera in this unit indicate that it was deposited in the deepest water and most open-marine conditions of all the Hawthorne deposits of Georgia. Manheim and Herring (Ch. IV) indicate that the lowermost, fine-grained section of the Pliocene in Borehole G contain evidence of primary phosphorite pellet formation.

On seismic reflection records the unit produces a poorly-layered to transparent signature almost entirely devoid of internal reflections (Figure VI-9). The unit contrasts sharply with the well-layered or banded appearance of the Middle Miocene strata. The unit forms a lateral infill sequence that fills the northern end of the inner-shelf low. It is thickest on the east flank of the mid-shelf high; most of the sediments appear to emanate from a northern and eastern source off the mouth of the Savannah River as though the source was deltaic, or strike-fed from the South Carolina shelf by southward-flowing shelf currents. The thick, sigmoidally eastward-prograding wedge of these sediments on the west flank of the mid-shelf high suggests that some of these sediments originate from reworking of the Miocene strata from the top of the mid-shelf high by wave-base or ravinement processes. The unit thins to zero thickness over parts of the mid-shelf high and seaward of the high pinches out before reaching the slope. The unit thins sigmoidally southward to pinch out just north of the St. Marys River. It is not present in offshore northern Florida.

Upper Pliocene (Piacenzian)

TACTS boreholes C, E, H, and JOIDES 1 penetrated calcareous sand, silt and silty clay, containing N-21 foraminifera, making the unit Piacinzian, or upper Pliocene, in age (Kennett and Srinivasan, 1983). These beds are equivalent in age to poorly sorted, calcareous, silty, shelly sands that have been found in borings on the coastal islands of Georgia, and to the Cypresshead Formation found at the foot of the Orangeburg Escarpment farther west (Huddlestun, 1988).

Seismic stratigraphic data show that the upper Pliocene strata are a lateral infilling sequence of southern end of the mid-shelf low and an upbuilding sequence at the shelf edge. The unit is thin to absent over parts of the mid-shelf high but forms a progradational upbuilding on the outer shelf at the slope edge where these sediments are up to 80 m thick (at the GE-1 well the unit is 52 m thick). The unit pinches out just landward of the slope and does not crop out due to the thick overlying section of Quaternary sands which form the present shelf edge. Within the mid-shelf low off the St. Marys River, the upper Pliocene reaches a thickness of 53 m just north of JOIDES 2. The character of the unit, similar to the Late Miocene and lower Pliocene, is seismically transparent, nearly devoid of internal reflectors (Popenoe, 1991).

The upper Pliocene strata prograde sigmoidally (indicating low energy conditions) from a northerly direction) into the mid-shelf low, downlapping the underlying lower Pliocene in the north and the late Miocene unconformity in the south, so that the oldest beds are found in the northern end of the mid-shelf low near the Savannah River, while the youngest beds of the sequence occur to the south,offshore Florida, and were penetrated in the JOIDES-2 well. Like the Late Miocene and Early Pliocene, they also prograde sigmoidally westward from the mid-shelf high into the inner-shelf low, indicating either a reworking of sediments from the top of the high or a lateral sediment input by shelf currents from the northeasterly direction. The top of the unit is incised by several large stream channels of up to 40 m relief indicating subareal exposure of the shelf at the close of the Pliocene.

Beneath the barrier islands along the Georgia coast the character of the late Pliocene sequence is one of oblique progradation (indicating high energy or deltaic conditions) from the Sea Island Escarpment into the western part of the inner-shelf low (Woolsey, 1976; Foley, 1981; Kellam, Shapiro, and Henry, 1989).

Quaternary

The tops of all of TACTS cores penetrated a thin section (generally <10 m) of calcareous to quartz rich sand with shell fragments below the sea floor. The sand cover is generally well-sorted, although poorly-sorted layers were encountered, as well as pebbles of lithified carbonate. The sediments were divided, based on foraminiferal data, into Lower Pleistocene, Upper Pleistocene, and Holocene age beds, although these strata were not subdivided by our seismic stratigraphic data.

The Pleistocene and Holocene shelly sands in Atlantic coastal Georgia (Satilla Formation of Huddlestun, 1988), are described as "a heterogeneous unit of variably fossiliferous, shelly sands and clays of offshore, inner Continental Shelf origin; predominently bedded to non-bedded barrier Island deposits --- and marsh deposits". The deposits are similar offshore, where marsh, barrier, and backbarrier sequences have been documented in vibracore

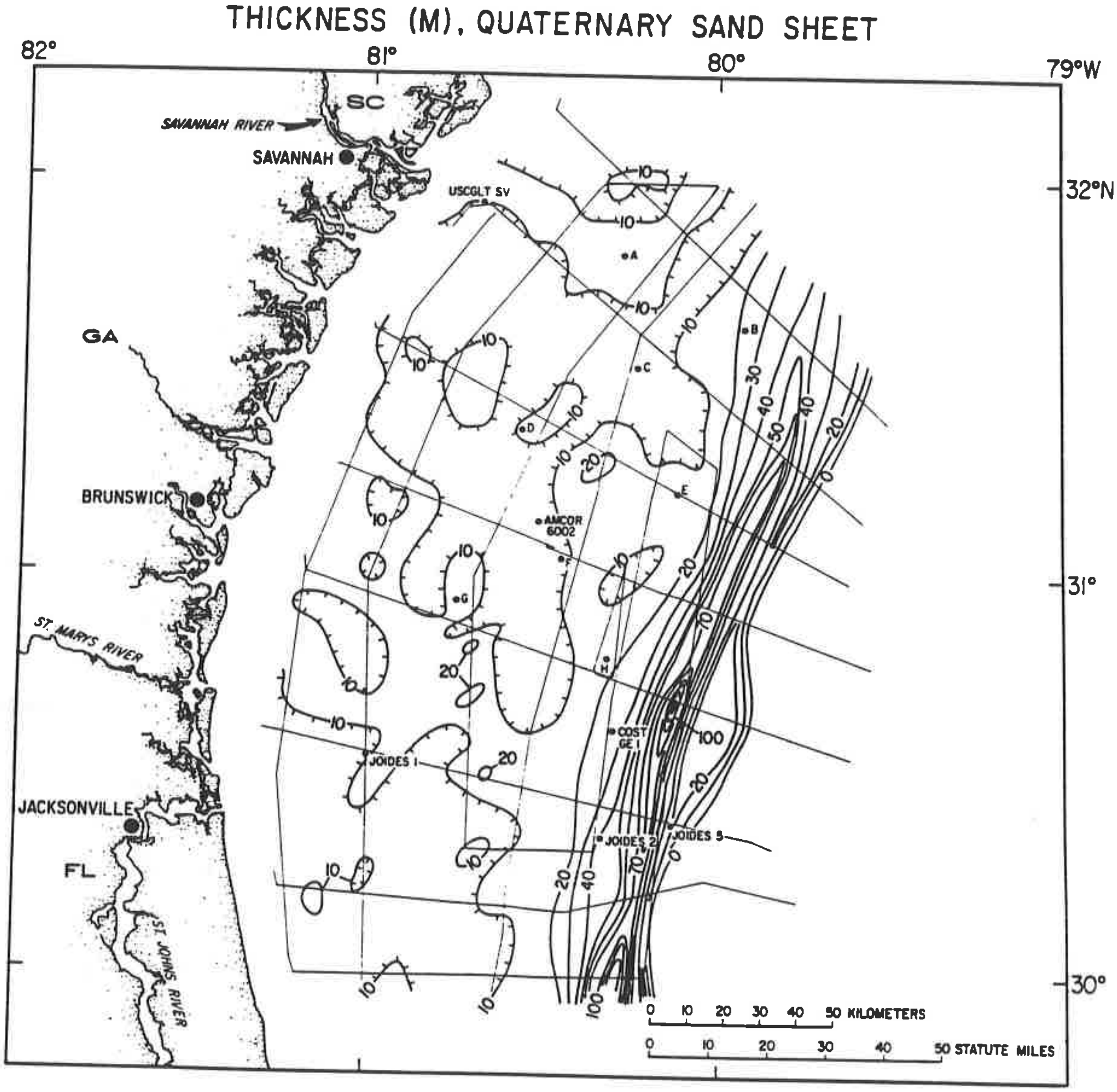


Figure VI-10. Thickness map for the Upper Quaternary sand sheet.

transects (Meisburger, 1977; Ayers and others, 1979) and by seismic data (Ayers and others, 1979, Henry and others, 1981).

Although the units can be divided by seismic stratigraphy we have not done so because of their thin and seismically transparent character. Since the units are thin and occur in the shallow subsurface, the boundaries dividing them usually occur within the bubble pulse of the sparker seismic system, the bottom reflection of the outgoing signal which obscured the upper 5 to 7.5 m of the subbottom, or the first bottom multiple. Of particular note on our seismic records are stream-channel fillings and cut and fill structures with tens of m relief, both of Pleistocene and Holocene age, that occur throughout the section in the shallow subsurface. Because of our wide line spacing (20 km) we were not able to trace these channels, but based on previous studies (Henry and others, 1981; Carpenter, 1981), they are known to be of fluvial and both through- and back-barrier tidal channel origin.

Both the seismic-stratigraphic and well data indicate that the Quaternary section over the shelf is fairly uniform in thickness, generally between 3 and 15 m on the inner and mid shelf. On the outer shelf the Quaternary beds form a progradational wedge that upbuilds and outbuilds the shelf edge. Because of this shelf-edge wedge, these beds reach a thickness of over 150 m on the outer shelf (Figure VI-10). Figure VI-11 presents a map of the sediment thickness of Lower and Upper Pliocene and Quaternary beds that overlie the most phosphatic unit, the Middle Miocene.

Conclusions

The geologic section penetrated by the TACTS coreholes represents normal coastal to marine deposition on a stable shelf during transgressing and regressing seas, similar to the coastal plain section onshore. The units thin and thicken and are variably discontinuous depending on the interplay of sediment supply and supply points, ocean circulation patterns, submarine and subaerial erosion, and the bathymetric relief prevalent at the time of their deposition. The system is driven mainly by variations in sea level and resulting changes in shelf current patterns and has little to do with tectonic influence other than minor shelf-edge tilting.

Depositional units related to variations in sea level are separated by regional unconformities that mark subareal exposure of the shelf, periods of marine erosion related to shoaling seas, or Gulf Stream incursions onto the outer shelf. Shallow-water conditions and probable exposure of the shelf during lowstands are implied from the prevalence of shallow water marine, fluvial, and esturine deposits preserved under the Coastal Plain and Continental Shelf. Deeper water conditions are implied by the presence of these units high on the Florida Platform (Ocala high) and by depositional sequences preserved across the shelf. The Miocene, Pliocene, and Quaternary sediments sampled by the TACTS cores are predominantly paralic or shelf deposition.

Deposition related to four of the five major Miocene sea level transgressive cycles are represented in the TACTS cores; the Aquatanian, Burdigalian, lower Serravallian, and late Tortonian. Deposition related to the Langhian is found in the COST GE-1 well, JOIDES 1 and 2, as well as the North Carolina shelf and onshore Florida. The Early Tortonian and Messinian are represented by a major unconformity cut on the top of the middle Miocene age rocks and strata of their ages is only found in AMCOR 6002.

The units, particularly those of the middle Miocene, have internal stratal unconformities probably related to marine erosional episodes during low sea level stands. The major phosphorite enrichment zones of the Miocene correlate with these intra-stratal unconformities, or with the major unconformities that separate the major sequences.

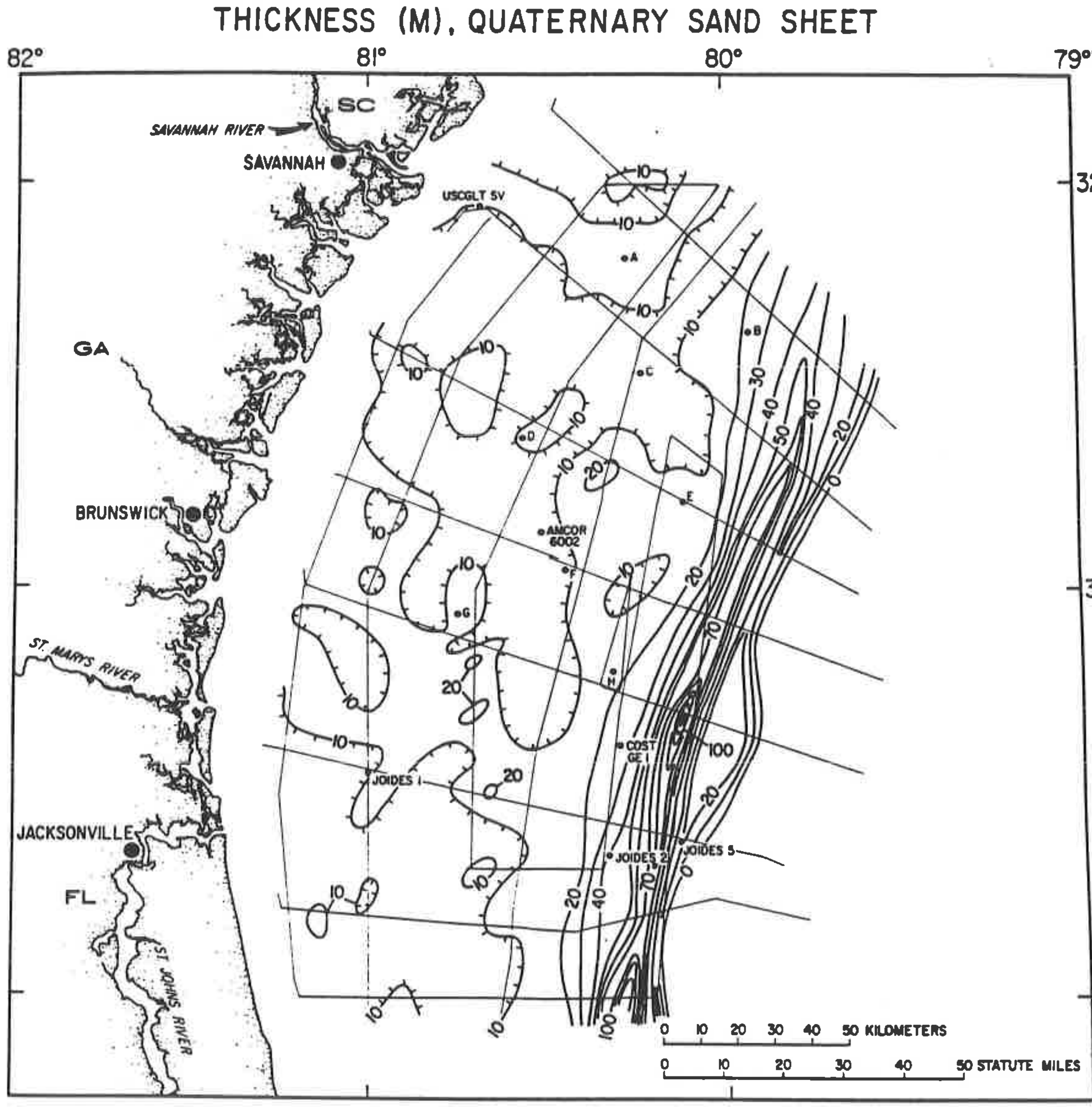


Figure VI-11. Thickness of sediments overlying Middle Miocene-aged sediments.

VII SUMMARY AND CONCLUSIONS

1) The geologic sections penetrated by the TACTS boreholes represent normal coastal to marine deposition on a stable shelf during transgressing and regressing seas, encompassing water depths from subaerial exposure to depths over 200m. The conditions resemble those for the coastal plain onshore. Units thin, thicken and are discontinuous depending on the interplay of sediment supply, ocean circulation, bathymetric relief and submarine erosion. This system is driven mainly by variations in sea level, with resulting change in current patterns and intensity, and have little to do with tectonics other than minor shelf-edge tilting.

2) Deposition related to five of the six major Late Oligocene through Miocene transgressive cycles: Rupelian, Aquitanian, Burdigalian, lower Serravallian, and late Tortonian. Deposition related to the Langhian is found in the COST GE-1 well, JOIDES 1 and 2, as well as on the North Carolina shelf and onshore Florida. The Late Miocene (The Early Tortonian and Messinian) regressions are represented by major unconformities cut into the top of the Middle Miocene age rocks. Sediments of these ages are only found in AMCOR 6002.

3) Primary phosphorite was preferentially deposited in the transgressive, deeper-water depositional sequences marked by nutrient upwelling from beneath the Gulf Stream and its eddies. Finer, organic-rich sediment provided the phosphate and minor carbonate which interacted in the interstitial water environment to produce phosphorite pellets. Subsequent higher-energy currents accompanying shallowing of waters produced increasing degrees of pellet transportation and selective enrichment, while finer sediments were winnowed out and transported to depositional sites ranging to from local basins to the continental slope. The most intensive phosphogenic period was during Middle Miocene time in the shelf off central-northern Georgia.

4) Primary phosphogenesis occurred already in Lower Oligocene time, especially in the southern region, and continued actively through Lower Pliocene time, and perhaps even beyond. These periods may be marked by relatively low phosphorite abundance in finer sediments, whereas the reworked, phosphate-enriched zones tend to occur in coarser zones within or atop finer sequences (erosional lag deposits).

5) The mean phosphorite content of Miocene strata is over 6% P_2O_5, corresponding to 16% bone phosphate of lime (BPL), or 20% carbonate fluorapatite (CFA), reaching values as high as 21.6% P_2O_5 (47.2 % BPL) in enriched zones, and locally even greater values. The overall mean value of BPL for over 200 samples from boreholes B, D, and H is between 4 and 5% BPL, more than 20 times the average of Atlantic marine sediments. The total phosphorite content (CFA) of the inner to middle shelf off Georgia (10,000 km^2) is estimated to be over 50 billion tons, but most of this phosphorite could only be recovered by borehole, or slurry mining, since it is too deep for hydraulic dredging. Environmental constraints would further suggest a preference for borehole mining.

6) Textural and petrographic analysis of the sediments revealed two criteria for identification of primary phosphorite pellets: presence of a coarser

pelletal phosphorite (textural outlier) phase within a finer-grained bottom sediment environment, and actual presence of phosphorite pellets in the state of formation inside foraminifera and other encapsulating organisms. Upon later reworking and transportation the pellets lose identifying markings, become smoother or abraded externally, and acquire oolitic or fresh phosphatic overlayers. Bone and shell fragments may be phosphatized, and larger grains to pebble or even cobble-size are formed. They also become darker, reaching an almost black color.

Except where marked re-aggregation of phosphorite could be identified, most sediments were characterized by a principal mode or median in the 2-3 phi range (.06 to .25mm), with the .125-.25 mm half-phi mode dominant.

7) Chemically, pure pellet end-member phases extrapolate to about 34 % P_2O_5, forming a carbonate fluorapatite with about 6 percent structural CO_2, and about .9% MgO. Most trace constituents except rare earths and strontium are preferentially associated with clayey or sulfide-rich sediments with an estimated 1 percent organic carbon, rather than the pure apatite phase. Uranium is enriched at a level of about 140 ppm (ug/g) in the purest apatite phases.

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Appendix 1a: Volumetric pellet data for Tacts borehole A. Heading abbreviations are as follows: MGU = mean grid units, D = pellet diameter, R = pellet radius, V = volume of pellet, T.V. = total pellet volume for sample, AV V = Average pellet volume, MF = magnification factor, TGD = true grain diameter, M TGD = mean true grain diameter, SD = standard deviation, and CV = standard deviation of true grain diameter/ mean true grain diameter

Sample #	Grain No.	MGU	D	R	V	T.V.	AVV		MF	TGD	M TGD	SD	CV
A1.1	1	1.1	1.1	0.55	0.69	2.06	1.34		0.30	0.33	0.236	0.125	0.53
	2	0.9	0.9	0.45	0.38				0.30	0.27			
	3	0.3	0.3	0.15	0.01				0.30	0.09			
	4	0.4	0.4	0.20	0.03				0.30	0.12			
	5	1.2	1.2	0.62	0.94				0.30	0.37			
	1	0.5	0.5	0.25	0.07	0.63			0.30	0.15	0.195	0.0387	0.20
	2	0.7	0.7	0.35	0.18				0.30	0.21			
	3	0.8	0.8	0.40	0.27				0.30	0.24			
	4	0.6	0.6	0.30	0.11				0.30	0.18			
A6.6	1	2.0	1.6	0.80	1.74	5.23	4.58		0.25	0.40	0.253	0.088	0.35
	2	0.5	0.5	0.25	0.07				0.25	0.13			
	3	1.0	1.0	0.50	0.52				0.25	0.25			
	4	1.2	1.2	0.60	0.87				0.25	0.30			
	5	1.0	1.0	0.50	0.52				0.25	0.25			
	6	1.3	1.3	0.65	1.06				0.25	0.33			
	7	0.7	0.7	0.35	0.18				0.25	0.18			
	8	0.8	0.8	0.40	0.27				0.25	0.20			
	1	1.1	1.1	0.55	0.69	3.93			0.30	0.33	0.259	0.122	0.47
	2	0.9	0.9	0.45	0.38				0.30	0.27			
	3	0.9	0.9	0.45	0.38				0.30	0.27			
	4	1.0	1.0	0.50	0.52				0.30	0.30			
	5	0.9	0.9	0.45	0.38				0.30	0.27			
	6	0.4	0.4	0.20	0.03				0.30	0.12			
	7	1.8	1.5	0.76	1.54				0.30	0.45			
	8	0.2	0.2	0.10	0.00				0.30	0.06			
A7.2	1	0.4	0.4	0.20	0.03	5.72	5.06		0.30	0.12	0.217	0.120	0.55
	2	1.5	1.4	0.69	1.24				0.30	0.41			
	3	1.0	1.0	0.50	0.52				0.30	0.30			
	4	0.2	0.2	0.10	0.00				0.30	0.06			
	5	0.5	0.5	0.25	0.07				0.30	0.15			
	6	1.8	1.5	0.76	1.54				0.30	0.45			
	7	0.2	0.2	0.10	0.00				0.30	0.06			
	8	0.3	0.3	0.15	0.01				0.30	0.09			
	9	1.0	1.0	0.50	0.52				0.30	0.30			
	10	0.7	0.7	0.35	0.18				0.30	0.21			
	11	0.6	0.6	0.30	0.11				0.30	0.18			
	12	0.9	0.9	0.45	0.38				0.30	0.27			
	13	1.1	1.1	0.55	0.69				0.30	0.33			
	14	0.4	0.4	0.20	0.03				0.30	0.12			
	15	0.8	0.8	0.40	0.27				0.30	0.24			
	16	0.6	0.6	0.30	0.11				0.30	0.18			
	1	3.0	2.0	0.98	2.74	4.40			0.30	0.59	0.255	0.181	Table
	2	0.9	0.9	0.45	0.38				0.30	0.27			
	3	0.4	0.4	0.20	0.03				0.30	0.12			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
59		4	0.1	0.1	0.05	0.00				0.30	0.03			
60		5	1.2	1.2	0.60	0.87				0.30	0.36			
61		6	0.6	0.6	0.30	0.11				0.30	0.18			
62		7	0.8	0.8	0.40	0.27				0.30	0.24			
63														
64	A9.3	1	1.0	1.0	0.50	0.52	4.67	5.31		0.25	0.25	0.163	0.068	0.42
65		2	0.5	0.5	0.25	0.07				0.25	0.13			
66		3	1.2	1.2	0.60	0.87				0.25	0.30			
67		4	0.9	0.9	0.45	0.38				0.25	0.23			
68		5	0.6	0.6	0.30	0.11				0.25	0.15			
69		6	0.7	0.7	0.35	0.18				0.25	0.18			
70		7	0.6	0.6	0.30	0.11				0.25	0.15			
71		8	0.9	0.9	0.45	0.38				0.25	0.23			
72		9	0.2	0.2	0.10	0.00				0.25	0.05			
73		10	0.1	0.1	0.05	0.00				0.25	0.03			
74		11	0.5	0.5	0.25	0.07				0.25	0.13			
75		12	0.8	0.8	0.40	0.27				0.25	0.20			
76		13	0.6	0.6	0.30	0.11				0.25	0.15			
77		14	0.5	0.5	0.25	0.07				0.25	0.13			
78		15	0.3	0.3	0.15	0.01				0.25	0.08			
79		16	0.9	0.9	0.45	0.38				0.25	0.23			
80		17	0.6	0.6	0.30	0.11				0.25	0.15			
81		18	0.8	0.8	0.40	0.27				0.25	0.20			
82		19	0.5	0.5	0.25	0.07				0.25	0.13			
83		20	0.9	0.9	0.45	0.38				0.25	0.23			
84		21	0.8	0.8	0.40	0.27				0.25	0.20			
85		22	0.4	0.4	0.20	0.03				0.25	0.10			
86														
87		1	1.0	1.0	0.50	0.52	5.95			0.21	0.21	0.148	0.063	0.42
88		2	1.0	1.0	0.50	0.52				0.21	0.21			
89		3	0.5	0.5	0.25	0.07				0.21	0.11			
90		4	0.2	0.2	0.10	0.00				0.21	0.04			
91		5	0.6	0.6	0.30	0.11				0.21	0.13			
92		6	0.5	0.5	0.25	0.07				0.21	0.11			
93		7	0.8	0.8	0.40	0.27				0.21	0.17			
94		8	0.9	0.9	0.45	0.38				0.21	0.19			
95		9	0.5	0.5	0.25	0.07				0.21	0.11			
96		10	0.8	0.8	0.40	0.27				0.21	0.17			
97		11	0.7	0.7	0.35	0.18				0.21	0.15			
98		12	1.0	1.0	0.50	0.52				0.21	0.21			
99		13	0.9	0.9	0.45	0.38				0.21	0.19			
100		14	1.1	1.1	0.55	0.69				0.21	0.23			
101		15	1.2	1.2	0.60	0.87				0.21	0.25			
102		16	0.8	0.8	0.40	0.27				0.21	0.17			
103		17	0.5	0.5	0.25	0.07				0.21	0.11			
104		18	0.9	0.9	0.45	0.38				0.21	0.19			
105		19	0.4	0.4	0.20	0.03				0.21	0.08			
106		20	0.8	0.8	0.40	0.27				0.21	0.17			
107		21	0.1	0.1	0.05	0.00				0.21	0.02			
108		22	0.3	0.3	0.15	0.01				0.21	0.06			
109														
110	A10.5	1	1.0	1.0	0.50	0.52	4.87	4.40		0.25	0.25	0.169	0.066	0.39
111		2	0.4	0.4	0.20	0.03				0.25	0.10			
112		3	0.5	0.5	0.25	0.07				0.25	0.13			
113		4	0.6	0.6	0.30	0.11				0.25	0.15			
114		5	0.7	0.7	0.35	0.18				0.25	0.18			
115		6	1.0	1.0	0.50	0.52				0.25	0.25			
116		7	0.7	0.7	0.35	0.18				0.25	0.18			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
117		8	0.9	0.9	0.45	0.38				0.25	0.23			
118		9	0.3	0.3	0.15	0.01				0.25	0.08			
119		10	0.8	0.8	0.40	0.27				0.25	0.20			
120		11	1.0	1.0	0.50	0.52				0.25	0.25			
121		12	0.5	0.5	0.25	0.07				0.25	0.13			
122		13	0.4	0.4	0.20	0.03				0.25	0.10			
123		14	0.9	0.9	0.45	0.38				0.25	0.23			
124		15	1.2	1.2	0.60	0.87				0.25	0.30			
125		16	0.4	0.4	0.20	0.03				0.25	0.10			
126		17	0.7	0.7	0.35	0.18				0.25	0.18			
127		18	0.6	0.6	0.30	0.11				0.25	0.15			
128		19	0.2	0.2	0.10	0.00				0.25	0.05			
129		20	0.6	0.6	0.30	0.11				0.25	0.15			
130		21	0.8	0.8	0.40	0.27				0.25	0.20			
131														
132		1	0.6	0.6	0.30	0.11	3.93			0.25	0.15	0.164	0.100	0.61
133		2	0.5	0.5	0.25	0.07				0.25	0.13			
134		3	0.2	0.2	0.10	0.00				0.25	0.05			
135		4	1.3	1.3	0.65	1.06				0.25	0.33			
136		5	1.1	1.1	0.55	0.69				0.25	0.28			
137		6	0.2	0.2	0.10	0.00				0.25	0.05			
138		7	0.4	0.4	0.20	0.03				0.25	0.10			
139		8	0.5	0.5	0.25	0.07				0.25	0.13			
140		9	1.0	1.0	0.50	0.52				0.25	0.25			
141		10	0.7	0.7	0.35	0.18				0.25	0.18			
142		11	1.4	1.3	0.67	1.14				0.25	0.33			
143		12	0.3	0.3	0.15	0.01				0.25	0.08			
144		13	0.4	0.4	0.20	0.03				0.25	0.10			
145														
146	A17.2	1	1.3	1.3	0.65	1.06	1.59	2.46		0.21	0.27	0.111	0.091	0.82
147		2	0.5	0.5	0.25	0.07				0.21	0.11			
148		3	0.2	0.2	0.10	0.00				0.21	0.04			
149		4	0.9	0.9	0.45	0.38				0.21	0.19			
150		5	0.1	0.1	0.05	0.00				0.21	0.02			
151		6	0.2	0.2	0.10	0.00				0.21	0.04			
152		7	0.5	0.5	0.25	0.07				0.21	0.11			
153														
154		1	0.6	0.6	0.30	0.11	3.34			0.21	0.13	0.136	0.096	0.71
155		2	0.6	0.6	0.30	0.11				0.21	0.13			
156		3	0.3	0.3	0.15	0.01				0.21	0.06			
157		4	0.1	0.1	0.05	0.00				0.21	0.02			
158		5	0.9	0.9	0.45	0.38				0.21	0.19			
159		6	0.4	0.4	0.20	0.03				0.21	0.08			
160		7	2.0	1.6	0.80	1.74				0.21	0.34			
161		8	0.5	0.5	0.25	0.07				0.21	0.11			
162		9	1.2	1.2	0.60	0.87				0.21	0.25			
163		10	0.3	0.3	0.15	0.01				0.21	0.06			
164														
165	A17.4	1	0.9	0.9	0.45	0.38	9.48	7.21		0.15	0.14	0.153	0.030	0.20
166		2	0.9	0.9	0.45	0.38				0.15	0.14			
167		3	1.2	1.2	0.60	0.87				0.15	0.18			
168		4	1.1	1.1	0.55	0.69				0.15	0.17			
169		5	0.9	0.9	0.45	0.38				0.15	0.14			
170		6	1.5	1.4	0.69	1.24				0.15	0.21			
171		7	1.2	1.2	0.60	0.87				0.15	0.18			
172		8	0.9	0.9	0.45	0.38				0.15	0.14			
173		9	0.8	0.8	0.40	0.27				0.15	0.12			
174		10	1.0	1.0	0.50	0.52				0.15	0.15			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
175		11	0.9	0.9	0.45	0.38				0.15	0.14			
176		12	1.3	1.3	0.65	1.06				0.15	0.20			
177		13	0.8	0.8	0.40	0.27				0.15	0.12			
178		14	0.9	0.9	0.45	0.38				0.15	0.14			
179		15	1.4	1.3	0.67	1.14				0.15	0.20			
180		16	0.8	0.8	0.40	0.27				0.15	0.12			
181														
182		1	0.9	0.9	0.45	0.38	4.94			0.15	0.14	0.118	0.054	0.46
183		2	1.2	1.2	0.60	0.87				0.15	0.18			
184		3	0.2	0.2	0.10	0.00				0.15	0.03			
185		4	2.0	1.6	0.80	1.74				0.15	0.24			
186		5	0.6	0.6	0.30	0.11				0.15	0.09			
187		6	0.8	0.8	0.40	0.27				0.15	0.12			
188		7	1.0	1.0	0.50	0.52				0.15	0.15			
189		8	0.5	0.5	0.25	0.07				0.15	0.08			
190		9	0.9	0.9	0.45	0.38				0.15	0.14			
191		10	0.8	0.8	0.40	0.27				0.15	0.12			
192		11	0.6	0.6	0.30	0.11				0.15	0.09			
193		12	0.7	0.7	0.35	0.18				0.15	0.11			
194		13	0.4	0.4	0.20	0.03				0.15	0.06			
195														
196	A17.7	1	0.9	0.9	0.45	0.38	8.24			0.21	0.19	0.137	0.089	0.65
197		2	0.2	0.2	0.10	0.00				0.21	0.04			
198		3	0.9	0.9	0.45	0.38				0.21	0.19			
199		4	0.8	0.8	0.40	0.27				0.21	0.17			
200		5	0.9	0.9	0.45	0.38				0.21	0.19			
201		6	0.2	0.2	0.10	0.00				0.21	0.04			
202		7	1.1	1.1	0.55	0.69				0.21	0.23			
203		8	0.3	0.3	0.15	0.01				0.21	0.06			
204		9	1.3	1.3	0.65	1.06				0.21	0.27			
205		10	0.6	0.6	0.30	0.11				0.21	0.13			
206		11	0.7	0.7	0.35	0.18				0.21	0.15			
207		12	0.5	0.5	0.25	0.07				0.21	0.11			
208		13	0.6	0.6	0.30	0.11				0.21	0.13			
209		14	0.8	0.8	0.40	0.27				0.21	0.17			
210		15	0.2	0.2	0.10	0.00				0.21	0.04			
211		16	1.3	1.3	0.65	1.06				0.21	0.27			
212		17	2.0	1.6	0.80	1.74				0.21	0.34			
213		18	0.2	0.2	0.10	0.00				0.21	0.04			
214		19	0.6	0.6	0.30	0.11				0.21	0.13			
215		20	0.3	0.3	0.15	0.01				0.21	0.06			
216		21	1.5	1.4	0.69	1.24				0.21	0.29			
217		22	0.4	0.4	0.20	0.03				0.21	0.08			
218		23	0.2	0.2	0.10	0.00				0.21	0.04			
219		24	0.5	0.5	0.25	0.07				0.21	0.11			
220		25	0.4	0.4	0.20	0.03				0.21	0.08			
221		26	0.1	0.1	0.05	0.00				0.21	0.02			
222														
223	A20.6	1	0.9	0.9	0.45	0.38	7.93			0.19	0.17	0.131	0.088	0.68
224		2	1.1	1.1	0.55	0.69				0.19	0.21			
225		3	0.5	0.5	0.25	0.07				0.19	0.10			
226		4	0.1	0.1	0.05	0.00				0.19	0.02			
227		5	0.1	0.1	0.05	0.00				0.19	0.02			
228		6	0.6	0.6	0.30	0.11				0.19	0.11			
229		7	1.8	1.5	0.76	1.54				0.19	0.29			
230		8	0.2	0.2	0.10	0.00				0.19	0.04			
231		9	0.5	0.5	0.25	0.07				0.19	0.10			
232		10	0.5	0.5	0.25	0.07				0.19	0.10			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
233		11	2.1	1.6	0.82	1.84				0.19	0.31			
234		12	0.8	0.8	0.40	0.27				0.19	0.15			
235		13	1.3	1.3	0.65	1.06				0.19	0.25			
236		14	0.4	0.4	0.20	0.03				0.19	0.08			
237		15	1.5	1.4	0.69	1.24				0.19	0.26			
238		16	0.5	0.5	0.25	0.07				0.19	0.10			
239		17	0.4	0.4	0.20	0.03				0.19	0.08			
240		18	0.8	0.8	0.40	0.27				0.19	0.15			
241		19	0.7	0.7	0.35	0.18				0.19	0.13			
242		20	0.3	0.3	0.15	0.01				0.19	0.06			
243		21	0.2	0.2	0.10	0.00				0.19	0.04			
244														
245	A25.9	1	0.8	0.8	0.40	0.27	1.81	3.94		0.21	0.17	0.156	0.043	0.28
246		2	0.7	0.7	0.35	0.18				0.21	0.15			
247		3	1.1	1.1	0.55	0.69				0.21	0.23			
248		4	0.9	0.9	0.45	0.38				0.21	0.19			
249		5	0.5	0.5	0.25	0.07				0.21	0.11			
250		6	0.6	0.6	0.30	0.11				0.21	0.13			
251		7	0.6	0.6	0.30	0.11				0.21	0.13			
252														
253		1	1.4	1.3	0.67	1.14	6.08			0.21	0.28	0.231	0.138	0.60
254		2	0.5	0.5	0.25	0.07				0.21	0.11			
255		3	4.0	2.3	1.13	3.74				0.21	0.47			
256		4	0.5	0.5	0.25	0.07				0.21	0.11			
257		5	0.9	0.9	0.45	0.38				0.21	0.19			
258		6	1.1	1.1	0.55	0.69				0.21	0.23			
259														
260	A26.0	1	0.9	0.9	0.45	0.38	10.17	11.28		0.13	0.12	0.176	0.050	0.28
261		2	0.9	0.9	0.45	0.38				0.13	0.12			
262		3	1.7	1.5	0.74	1.44				0.13	0.19			
263		4	2.9	1.9	0.96	2.64				0.13	0.25			
264		5	1.1	1.1	0.55	0.69				0.13	0.14			
265		6	2.3	1.7	0.86	2.04				0.13	0.22			
266		7	1.2	1.2	0.60	0.87				0.13	0.16			
267		8	2.0	1.6	0.80	1.74				0.13	0.21			
268														
269		1	3.0	2.0	0.98	2.74	12.38			0.13	0.25	0.179	0.059	0.33
270		2	1.0	1.0	0.50	0.52				0.13	0.13			
271		3	1.5	1.4	0.69	1.24				0.13	0.18			
272		4	2.0	1.6	0.80	1.74				0.13	0.21			
273		5	1.1	1.1	0.55	0.69				0.13	0.14			
274		6	3.2	2.0	1.01	2.94				0.13	0.26			
275		7	1.8	1.5	0.76	1.54				0.13	0.20			
276		8	0.6	0.6	0.30	0.11				0.13	0.08			
277		9	1.2	1.2	0.60	0.87				0.13	0.16			
278														
279	A26.1	1	0.9	0.9	0.45	0.38	7.61			0.17	0.15	0.160	0.091	0.57
280		2	1.4	1.3	0.67	1.14				0.17	0.23			
281		3	0.2	0.2	0.10	0.00				0.17	0.03			
282		4	0.6	0.6	0.30	0.11				0.17	0.10			
283		5	0.9	0.9	0.45	0.38				0.17	0.15			
284		6	0.9	0.9	0.45	0.38				0.17	0.15			
285		7	1.0	1.0	0.50	0.52				0.17	0.17			
286		8	3.5	2.1	1.06	3.24				0.17	0.36			
287		9	0.9	0.9	0.45	0.38				0.17	0.15			
288		10	0.2	0.2	0.10	0.00				0.17	0.03			
289		11	1.3	1.3	0.65	1.06				0.17	0.22			
290														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
291	A26.2	1	1.0	1.0	0.50	0.52	4.86	4.76		0.21	0.21	0.162	0.059	0.36
292		2	0.9	0.9	0.45	0.38				0.21	0.19			
293		3	0.7	0.7	0.35	0.18				0.21	0.15			
294		4	0.5	0.5	0.25	0.07				0.21	0.11			
295		5	0.5	0.5	0.25	0.07				0.21	0.11			
296		6	0.7	0.7	0.35	0.18				0.21	0.15			
297		7	1.2	1.2	0.60	0.87				0.21	0.25			
298		8	0.9	0.9	0.45	0.38				0.21	0.19			
299		9	0.8	0.8	0.40	0.27				0.21	0.17			
300		10	0.6	0.6	0.30	0.11				0.21	0.13			
301		11	0.8	0.8	0.40	0.27				0.21	0.17			
302		12	0.2	0.2	0.10	0.00				0.21	0.04			
303		13	0.6	0.6	0.30	0.11				0.21	0.13			
304		14	0.9	0.9	0.45	0.38				0.21	0.19			
305		15	1.3	1.3	0.65	1.06				0.21	0.27			
306														
307		1	0.9	0.9	0.45	0.38	4.67			0.21	0.19	0.169	0.071	0.42
308		2	0.8	0.8	0.40	0.27				0.21	0.17			
309		3	0.8	0.8	0.40	0.27				0.21	0.17			
310		4	1.5	1.4	0.69	1.24				0.21	0.29			
311		5	0.4	0.4	0.20	0.03				0.21	0.08			
312		6	1.0	1.0	0.50	0.52				0.21	0.21			
313		7	1.2	1.2	0.60	0.87				0.21	0.25			
314		8	0.2	0.2	0.10	0.00				0.21	0.04			
315		9	0.6	0.6	0.30	0.11				0.21	0.13			
316		10	0.5	0.5	0.25	0.07				0.21	0.11			
317		11	0.9	0.9	0.45	0.38				0.21	0.19			
318		12	1.0	1.0	0.50	0.52				0.21	0.21			
319														
320	A27.4	1	1.7	1.5	0.74	1.44	5.23	8.54		0.15	0.22	0.123	0.056	0.46
321		2	1.0	1.0	0.50	0.52				0.15	0.15			
322		3	0.6	0.6	0.30	0.11				0.15	0.09			
323		4	0.5	0.5	0.25	0.07				0.15	0.08			
324		5	1.0	1.0	0.50	0.52				0.15	0.15			
325		6	0.7	0.7	0.35	0.18				0.15	0.11			
326		7	1.2	1.2	0.60	0.87				0.15	0.18			
327		8	1.5	1.4	0.69	1.24				0.15	0.21			
328		9	0.5	0.5	0.25	0.07				0.15	0.08			
329		10	0.4	0.4	0.20	0.03				0.15	0.06			
330		11	0.6	0.6	0.30	0.11				0.15	0.09			
331		12	0.5	0.5	0.25	0.07				0.15	0.08			
332														
333		1	2.0	1.6	0.80	1.74	11.85			0.15	0.24	0.150	0.073	0.49
334		2	1.7	1.5	0.74	1.44				0.15	0.22			
335		3	0.8	0.8	0.40	0.27				0.15	0.12			
336		4	2.3	1.7	0.86	2.04				0.15	0.26			
337		5	0.9	0.9	0.45	0.38				0.15	0.14			
338		6	0.8	0.8	0.40	0.27				0.15	0.12			
339		7	1.2	1.2	0.60	0.87				0.15	0.18			
340		8	2.5	1.8	0.89	2.24				0.15	0.27			
341		9	1.2	1.2	0.60	0.87				0.15	0.18			
342		10	1.0	1.0	0.50	0.52				0.15	0.15			
343		11	0.9	0.9	0.45	0.38				0.15	0.14			
344		12	0.2	0.2	0.10	0.00				0.15	0.03			
345		13	0.5	0.5	0.25	0.07				0.15	0.08			
346		14	0.5	0.5	0.25	0.07				0.15	0.08			
347		15	0.3	0.3	0.15	0.01				0.15	0.05			
348		16	1.1	1.1	0.55	0.69				0.15	0.17			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
349														
350	A27.6	1	1.1	1.1	0.55	0.69	15.21	10.17		0.15	0.17	0.172	0.080	0.47
351		2	0.4	0.4	0.20	0.03				0.15	0.06			
352		3	0.7	0.7	0.35	0.18				0.15	0.11			
353		4	2.5	1.8	0.89	2.24				0.15	0.27			
354		5	0.5	0.5	0.25	0.07				0.15	0.08			
355		6	2.3	1.7	0.86	2.04				0.15	0.26			
356		7	0.6	0.6	0.30	0.11				0.15	0.09			
357		8	1.4	1.3	0.67	1.14				0.15	0.20			
358		9	2.3	1.7	0.86	2.04				0.15	0.26			
359		10	3.0	2.0	0.98	2.74				0.15	0.29			
360		11	2.5	1.8	0.89	2.24				0.15	0.27			
361		12	0.9	0.9	0.45	0.38				0.15	0.14			
362		13	0.6	0.6	0.30	0.11				0.15	0.09			
363		14	1.1	1.1	0.55	0.69				0.15	0.17			
364		15	1.0	1.0	0.50	0.52				0.15	0.15			
365														
366		1	0.4	0.4	0.20	0.03	5.12			0.15	0.06	0.132	0.072	0.54
367		2	2.2	1.7	0.84	1.94				0.15	0.25			
368		3	1.3	1.3	0.65	1.06				0.15	0.20			
369		4	0.9	0.9	0.45	0.38				0.15	0.14			
370		5	0.6	0.6	0.30	0.11				0.15	0.09			
371		6	0.8	0.8	0.40	0.27				0.15	0.12			
372		7	0.7	0.7	0.35	0.18				0.15	0.11			
373		8	1.4	1.3	0.67	1.14				0.15	0.20			
374		9	0.2	0.2	0.10	0.00				0.15	0.03			
375														
376	A33.1	1	1.1	1.1	0.55	0.69	10.55	9.78		0.15	0.17	0.153	0.050	0.32
377		2	1.0	1.0	0.50	0.52				0.15	0.15			
378		3	0.5	0.5	0.25	0.07				0.15	0.08			
379		4	1.1	1.1	0.55	0.69				0.15	0.17			
380		5	1.5	1.4	0.69	1.24				0.15	0.21			
381		6	1.2	1.2	0.60	0.87				0.15	0.18			
382		7	0.6	0.6	0.30	0.11				0.15	0.09			
383		8	1.2	1.2	0.60	0.87				0.15	0.18			
384		9	0.8	0.8	0.40	0.27				0.15	0.12			
385		10	1.0	1.0	0.50	0.52				0.15	0.15			
386		11	0.6	0.6	0.30	0.11				0.15	0.09			
387		12	1.2	1.2	0.60	0.87				0.15	0.18			
388		13	0.8	0.8	0.40	0.27				0.15	0.12			
389		14	0.7	0.7	0.35	0.18				0.15	0.11			
390		15	1.8	1.5	0.76	1.54				0.15	0.23			
391		16	2.0	1.6	0.80	1.74				0.15	0.24			
392														
393		1	5.0	2.5	1.26	4.74	9.01			0.15	0.38	0.153	0.111	0.72
394		2	0.8	0.8	0.40	0.27				0.15	0.12			
395		3	1.9	1.6	0.78	1.64				0.15	0.23			
396		4	2.2	1.7	0.84	1.94				0.15	0.25			
397		5	0.6	0.6	0.30	0.11				0.15	0.09			
398		6	0.4	0.4	0.20	0.03				0.15	0.06			
399		7	0.7	0.7	0.35	0.18				0.15	0.11			
400		8	0.5	0.5	0.25	0.07				0.15	0.08			
401		9	0.4	0.4	0.20	0.03				0.15	0.06			
402														
403	A33.4	1	0.8	0.8	0.40	0.27	4.31	4.37		0.19	0.15	0.162	0.063	0.39
404		2	0.9	0.9	0.45	0.38				0.19	0.17			
405		3	0.4	0.4	0.20	0.03				0.19	0.08			
406		4	1.8	1.5	0.76	1.54				0.19	0.29			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
407		5	0.9	0.9	0.45	0.38				0.19	0.17			
408		6	0.3	0.3	0.15	0.01				0.19	0.06			
409		7	0.8	0.8	0.40	0.27				0.19	0.15			
410		8	1.0	1.0	0.50	0.52				0.19	0.19			
411		9	0.9	0.9	0.45	0.38				0.19	0.17			
412		10	1.0	1.0	0.50	0.52				0.19	0.19			
413														
414		1	2.2	1.7	0.84	1.94	4.43			0.19	0.32	0.170	0.084	0.49
415		2	0.9	0.9	0.45	0.38				0.19	0.17			
416		3	0.5	0.5	0.25	0.07				0.19	0.10			
417		4	1.0	1.0	0.50	0.52				0.19	0.19			
418		5	0.8	0.8	0.40	0.27				0.19	0.15			
419		6	0.2	0.2	0.10	0.00				0.19	0.04			
420		7	0.9	0.9	0.45	0.38				0.19	0.17			
421		8	1.2	1.2	0.60	0.87				0.19	0.23			
422														
423	A36.6	1	1.1	1.1	0.55	0.69	4.45	2.77		0.25	0.28	0.188	0.111	0.59
424		2	0.8	0.8	0.40	0.27				0.25	0.20			
425		3	1.9	1.6	0.78	1.64				0.25	0.39			
426		4	1.1	1.1	0.55	0.69				0.25	0.28			
427		5	0.5	0.5	0.25	0.07				0.25	0.13			
428		6	1.0	1.0	0.50	0.52				0.25	0.25			
429		7	0.7	0.7	0.35	0.18				0.25	0.18			
430		8	0.9	0.9	0.45	0.38				0.25	0.23			
431		9	0.3	0.3	0.15	0.01				0.25	0.08			
432		10	0.1	0.1	0.05	0.00				0.25	0.03			
433		11	0.2	0.2	0.10	0.00				0.25	0.05			
434														
435		1	1.1	1.1	0.55	0.69	1.08			0.25	0.28	0.117	0.074	0.63
436		2	0.4	0.4	0.20	0.03				0.25	0.10			
437		3	0.5	0.5	0.25	0.07				0.25	0.13			
438		4	0.3	0.3	0.15	0.01				0.25	0.08			
439		5	0.1	0.1	0.05	0.00				0.25	0.03			
440		6	0.2	0.2	0.10	0.00				0.25	0.05			
441		7	0.7	0.7	0.35	0.18				0.25	0.18			
442		8	0.4	0.4	0.20	0.03				0.25	0.10			
443		9	0.5	0.5	0.25	0.07				0.25	0.13			
444														
445	A39.6	1	6.0	2.8	1.38	5.74	7.95	13.74		0.33	0.91	0.228	0.200	0.88
446		2	0.5	0.5	0.25	0.07				0.33	0.17			
447		3	0.7	0.7	0.35	0.18				0.33	0.23			
448		4	0.2	0.2	0.10	0.00				0.33	0.07			
449		5	0.4	0.4	0.20	0.03				0.33	0.13			
450		6	0.5	0.5	0.25	0.07				0.33	0.17			
451		7	0.9	0.9	0.45	0.38				0.33	0.30			
452		8	0.5	0.5	0.25	0.07				0.33	0.17			
453		9	1.1	1.1	0.55	0.69				0.33	0.36			
454		10	0.6	0.6	0.30	0.11				0.33	0.20			
455		11	0.4	0.4	0.20	0.03				0.33	0.13			
456		12	0.3	0.3	0.15	0.01				0.33	0.10			
457		13	0.9	0.9	0.45	0.38				0.33	0.30			
458		14	0.2	0.2	0.10	0.00				0.33	0.07			
459		15	0.5	0.5	0.25	0.07				0.33	0.17			
460		16	0.6	0.6	0.30	0.11				0.33	0.20			
461														
462		1	1.0	1.0	0.50	0.52	19.54			0.15	0.15	0.221	0.101	0.46
463		2	2.3	1.7	0.86	2.04				0.15	0.26			
464		3	0.4	0.4	0.20	0.03				0.15	0.06			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
465		4	1.1	1.1	0.55	0.69				0.15	0.17			
466		5	6.5	2.9	1.44	6.24				0.15	0.43			
467		6	4.4	2.4	1.18	4.14				0.15	0.36			
468		7	1.2	1.2	0.60	0.87				0.15	0.18			
469		8	1.5	1.4	0.69	1.24				0.15	0.21			
470		9	1.3	1.3	0.65	1.06				0.15	0.20			
471		10	2.1	1.6	0.82	1.84				0.15	0.25			
472		11	1.2	1.2	0.60	0.87				0.15	0.18			
473														
474	A39.8	1	1.2	1.2	0.60	0.87	21.28			0.21	0.25	0.215	0.095	0.44
475		2	2.0	1.6	0.80	1.74				0.21	0.34			
476		3	0.8	0.8	0.40	0.27				0.21	0.17			
477		4	1.3	1.3	0.65	1.06				0.21	0.27			
478		5	2.1	1.6	0.82	1.84				0.21	0.34			
479		6	0.5	0.5	0.25	0.07				0.21	0.11			
480		7	0.2	0.2	0.10	0.00				0.21	0.04			
481		8	0.6	0.6	0.30	0.11				0.21	0.13			
482		9	1.1	1.1	0.55	0.69				0.21	0.23			
483		10	1.0	1.0	0.50	0.52				0.21	0.21			
484		11	1.1	1.1	0.55	0.69				0.21	0.23			
485		12	0.9	0.9	0.45	0.38				0.21	0.19			
486		13	2.0	1.6	0.80	1.74				0.21	0.34			
487		14	0.9	0.9	0.45	0.38				0.21	0.19			
488		15	0.2	0.2	0.10	0.00				0.21	0.04			
489		16	0.3	0.3	0.15	0.01				0.21	0.06			
490		17	0.1	0.1	0.05	0.00				0.21	0.02			
491		18	1.4	1.3	0.67	1.14				0.21	0.28			
492		19	1.0	1.0	0.50	0.52				0.21	0.21			
493		20	1.3	1.3	0.65	1.06				0.21	0.27			
494		21	2.1	1.6	0.82	1.84				0.21	0.34			
495		22	1.0	1.0	0.50	0.52				0.21	0.21			
496		23	1.0	1.0	0.50	0.52				0.21	0.21			
497		24	1.3	1.3	0.65	1.06				0.21	0.27			
498		25	2.0	1.6	0.80	1.74				0.21	0.34			
499		26	1.2	1.2	0.60	0.87				0.21	0.25			
500		27	1.5	1.4	0.69	1.24				0.21	0.29			
501		28	0.9	0.9	0.45	0.38				0.21	0.19			
502														
503	A39.7	1	1.3	1.3	0.65	1.06	25.02	16.81		0.30	0.39	0.222	0.276	1.25
504		2	0.2	0.2	0.10	0.00				0.30	0.06			
505		3	0.2	0.2	0.10	0.00				0.30	0.06			
506		4	0.4	0.4	0.20	0.03				0.30	0.12			
507		5	0.5	0.5	0.25	0.07				0.30	0.15			
508		6	1.1	1.1	0.55	0.69				0.30	0.33			
509		7	1.0	1.0	0.50	0.52				0.30	0.30			
510		8	0.5	0.5	0.25	0.07				0.30	0.15			
511		9	0.2	0.2	0.10	0.00				0.30	0.06			
512		10	0.4	0.4	0.20	0.03				0.30	0.12			
513		11	1.3	1.3	0.65	1.06				0.30	0.39			
514		12	0.6	0.6	0.30	0.11				0.30	0.18			
515		13	0.5	0.5	0.25	0.07				0.30	0.15			
516		14	20.0	5.0	2.52	19.74				0.30	1.51			
517		15	0.9	0.9	0.45	0.38				0.30	0.27			
518		16	1.0	1.0	0.50	0.52				0.30	0.30			
519		17	0.5	0.5	0.25	0.07				0.30	0.15			
520		18	0.5	0.5	0.25	0.07				0.30	0.15			
521		19	0.3	0.3	0.15	0.01				0.30	0.09			
522		20	0.4	0.4	0.20	0.03				0.30	0.12			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
523		21	0.5	0.5	0.25	0.07				0.30	0.15			
524		22	0.4	0.4	0.20	0.03				0.30	0.12			
525		23	0.2	0.2	0.10	0.00				0.30	0.06			
526		24	0.2	0.2	0.10	0.00				0.30	0.06			
527		25	0.5	0.5	0.25	0.07				0.30	0.15			
528		26	0.7	0.7	0.35	0.18				0.30	0.21			
529		27	0.6	0.6	0.30	0.11				0.30	0.18			
530														
531		1	3.8	2.2	1.10	3.54	8.61			0.30	0.66	0.228	0.162	0.71
532		2	0.6	0.6	0.30	0.11				0.30	0.18			
533		3	1.3	1.3	0.65	1.06				0.30	0.39			
534		4	0.5	0.5	0.25	0.07				0.30	0.15			
535		5	0.5	0.5	0.25	0.07				0.30	0.15			
536		6	0.4	0.4	0.20	0.03				0.30	0.12			
537		7	1.0	1.0	0.50	0.52				0.30	0.30			
538		8	0.2	0.2	0.10	0.00				0.30	0.06			
539		9	0.3	0.3	0.15	0.01				0.30	0.09			
540		10	0.4	0.4	0.20	0.03				0.30	0.12			
541		11	0.2	0.2	0.10	0.00				0.30	0.06			
542		12	0.3	0.3	0.15	0.01				0.30	0.09			
543		13	1.4	1.3	0.67	1.14				0.30	0.40			
544		14	1.5	1.4	0.69	1.24				0.30	0.41			
545		15	0.9	0.9	0.45	0.38				0.30	0.27			
546		16	0.6	0.6	0.30	0.11				0.30	0.18			
547		17	0.8	0.8	0.40	0.27				0.30	0.24			
548														
549	A39.9	1	2.7	1.9	0.93	2.44	11.01	13.37		0.25	0.46	0.273	0.157	0.57
550		2	0.5	0.5	0.25	0.07				0.25	0.13			
551		3	0.5	0.5	0.25	0.07				0.25	0.13			
552		4	1.0	1.0	0.50	0.52				0.25	0.25			
553		5	1.2	1.2	0.60	0.87				0.25	0.30			
554		6	1.0	1.0	0.50	0.52				0.25	0.25			
555		7	4.3	2.3	1.17	4.04				0.25	0.59			
556		8	2.3	1.7	0.86	2.04				0.25	0.43			
557		9	0.6	0.6	0.30	0.11				0.25	0.15			
558		10	0.8	0.8	0.40	0.27				0.25	0.20			
559		11	0.5	0.5	0.25	0.07				0.25	0.13			
560														
561		1	3.6	2.1	1.07	3.34	15.74			0.25	0.54	0.235	0.158	0.67
562		2	1.0	1.0	0.50	0.52				0.25	0.25			
563		3	1.2	1.2	0.60	0.87				0.25	0.30			
564		4	6.7	2.9	1.46	6.44				0.25	0.73			
565		5	0.6	0.6	0.30	0.11				0.25	0.15			
566		6	0.9	0.9	0.45	0.38				0.25	0.23			
567		7	0.4	0.4	0.20	0.03				0.25	0.10			
568		8	1.3	1.3	0.65	1.06				0.25	0.33			
569		9	0.7	0.7	0.35	0.18				0.25	0.18			
570		10	0.2	0.2	0.10	0.00				0.25	0.05			
571		11	1.0	1.0	0.50	0.52				0.25	0.25			
572		12	0.5	0.5	0.25	0.07				0.25	0.13			
573		13	0.5	0.5	0.25	0.07				0.25	0.13			
574		14	0.8	0.8	0.40	0.27				0.25	0.20			
575		15	1.2	1.2	0.60	0.87				0.25	0.30			
576		16	0.9	0.9	0.45	0.38				0.25	0.23			
577		17	0.5	0.5	0.25	0.07				0.25	0.13			
578		18	0.5	0.5	0.25	0.07				0.25	0.13			
579		19	0.9	0.9	0.45	0.38				0.25	0.23			
580		20	0.6	0.6	0.30	0.11				0.25	0.15			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
581														
582	A42.8	1	3.3	2.1	1.03	3.04	3.49	4.41		0.12	0.25	0.142	0.090	0.64
583		2	0.7	0.7	0.35	0.18				0.12	0.08			
584		3	0.8	0.8	0.40	0.27				0.12	0.10			
585														
586		1	2.7	1.9	0.93	2.44	5.34			0.12	0.22	0.192	0.034	0.17
587		2	1.3	1.3	0.65	1.06				0.12	0.16			
588		3	2.1	1.6	0.82	1.84				0.12	0.20			
589														
590	A72.2	1	1.2	1.2	0.60	0.87	3.12	3.12		0.12	0.14	0.102	0.074	0.72
591		2	0.1	0.1	0.05	0.00				0.12	0.01			
592		3	2.1	1.6	0.82	1.84				0.12	0.20			
593		4	0.4	0.4	0.20	0.03				0.12	0.05			
594		5	0.9	0.9	0.45	0.38				0.12	0.11			
595														
596		1	0.9	0.9	0.45	0.38	3.12			0.12	0.11	0.171	0.090	0.52
597		2	3.0	2.0	0.98	2.74				0.12	0.23			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Appendix 1b: Volumetric pellet data for TACTS borehole C.													
2														
3														
4	Sample #	Grain no.	MGU	D	R	V	T. V.	AVV		MF	TGD	M TGI	STDEV	CV
5														
6	C9.3	1	1.0	1.0	0.50	0.52	9.40	7.41		0.21	0.21	0.27	0.18	0.66
7		2	1.0	1.0	0.50	0.52				0.21	0.21			
8		3	1.2	1.2	0.60	0.87				0.21	0.25			
9		4	6.0	2.8	1.38	5.74				0.21	0.58			
10		5	2.0	1.6	0.80	1.74				0.21	0.34			
11		6	0.2	0.2	0.10	0.00				0.21	0.04			
12														
13	C10.4	1	1.0	1.0	0.50	0.52	5.42			0.30	0.30	0.20	0.12	0.58
14		2	1.0	1.0	0.50	0.52				0.30	0.30			
15		3	0.1	0.1	0.05	0.00				0.30	0.03			
16		4	0.5	0.5	0.25	0.07				0.30	0.15			
17		5	0.4	0.4	0.20	0.03				0.30	0.12			
18		6	0.2	0.2	0.10	0.00				0.30	0.06			
19		7	0.9	0.9	0.45	0.38				0.30	0.27			
20		8	1.0	1.0	0.50	0.52				0.30	0.30			
21		9	1.0	1.0	0.50	0.52				0.30	0.30			
22		10	0.4	0.4	0.20	0.03				0.30	0.12			
23		11	0.2	0.2	0.10	0.00				0.30	0.06			
24		12	0.9	0.9	0.45	0.38				0.30	0.27			
25		13	1.5	1.4	0.69	1.24				0.30	0.41			
26		14	0.6	0.6	0.30	0.11				0.30	0.18			
27		15	1.0	1.0	0.50	0.52				0.30	0.30			
28		16	0.2	0.2	0.10	0.00				0.30	0.06			
29		17	1.0	1.0	0.50	0.52				0.30	0.30			
30		18	0.3	0.3	0.15	0.01				0.30	0.09			
31														
32	C11.3	1	2.0	1.6	0.80	1.74	9.60	9.73		0.12	0.19	0.14	0.08	0.53
33		2	3.0	2.0	0.98	2.74				0.12	0.23			
34		3	1.2	1.2	0.60	0.87				0.12	0.14			
35		4	0.2	0.2	0.10	0.00				0.12	0.02			
36		5	3.0	2.0	0.98	2.74				0.12	0.23			
37		6	1.3	1.3	0.65	1.06				0.12	0.16			
38		7	0.5	0.5	0.25	0.07				0.12	0.06			
39		8	0.9	0.9	0.45	0.38				0.12	0.11			
40														
41		1	2.1	1.6	0.82	1.84	9.85			0.12	0.20	0.12	0.09	0.79
42		2	1.2	1.2	0.60	0.87				0.12	0.14			
43		3	1.7	1.5	0.74	1.44				0.12	0.18			
44		4	0.1	0.1	0.05	0.00				0.12	0.01			
45		5	0.2	0.2	0.10	0.00				0.12	0.02			
46		6	3.8	2.2	1.10	3.54				0.12	0.26			
47		7	1.9	1.6	0.78	1.64				0.12	0.19			
48		8	1.0	1.0	0.50	0.52				0.12	0.12			
49		9	0.1	0.1	0.05	0.00				0.12	0.01			
50		10	0.2	0.2	0.10	0.00				0.12	0.02			
51														
52	C20.7	1	3.8	2.2	1.10	3.54	12.58	12.69		0.15	0.33	0.17	0.08	0.45
53		2	0.9	0.9	0.45	0.38				0.15	0.14			
54		3	0.8	0.8	0.40	0.27				0.15	0.12			
55		4	2.7	1.9	0.93	2.44				0.15	0.28			
56		5	0.8	0.8	0.40	0.27				0.15	0.12			
57		6	0.6	0.6	0.30	0.11				0.15	0.09			
58		7	2.4	1.7	0.87	2.14				0.15	0.26			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
59		8	1.1	1.1	0.55	0.69				0.15	0.17			
60		9	1.3	1.3	0.65	1.06				0.15	0.20			
61		10	1.0	1.0	0.50	0.52				0.15	0.15			
62		11	1.2	1.2	0.60	0.87				0.15	0.18			
63		12	0.6	0.6	0.30	0.11				0.15	0.09			
64		13	0.7	0.7	0.35	0.18				0.15	0.11			
65														
66		1	0.3	0.3	0.15	0.01	12.80			0.15	0.05	0.14	0.11	0.84
67		2	0.2	0.2	0.10	0.00				0.15	0.03			
68		3	2.0	1.6	0.80	1.74				0.15	0.24			
69		4	0.1	0.1	0.05	0.00				0.15	0.02			
70		5	0.2	0.2	0.10	0.00				0.15	0.03			
71		6	0.1	0.1	0.05	0.00				0.15	0.02			
72		7	4.1	2.3	1.14	3.84				0.15	0.34			
73		8	3.4	2.1	1.04	3.14				0.15	0.31			
74		9	0.6	0.6	0.30	0.11				0.15	0.09			
75		10	0.6	0.6	0.30	0.11				0.15	0.09			
76		11	2.3	1.7	0.86	2.04				0.15	0.26			
77		12	0.7	0.7	0.35	0.18				0.15	0.11			
78		13	0.9	0.9	0.45	0.38				0.15	0.14			
79		14	1.5	1.4	0.69	1.24				0.15	0.21			
80														
81	C20.9	1	0.7	0.7	0.35	0.18	15.91	17.74		0.19	0.13	0.17	0.10	0.59
82		2	0.8	0.8	0.40	0.27				0.19	0.15			
83		3	0.5	0.5	0.25	0.07				0.19	0.10			
84		4	0.6	0.6	0.30	0.11				0.19	0.11			
85		5	0.5	0.5	0.25	0.07				0.19	0.10			
86		6	1.2	1.2	0.60	0.87				0.19	0.23			
87		7	0.6	0.6	0.30	0.11				0.19	0.11			
88		8	1.3	1.3	0.65	1.06				0.19	0.25			
89		9	0.5	0.5	0.25	0.07				0.19	0.10			
90		10	0.5	0.5	0.25	0.07				0.19	0.10			
91		11	0.7	0.7	0.35	0.18				0.19	0.13			
92		12	0.8	0.8	0.40	0.27				0.19	0.15			
93		13	2.4	1.7	0.87	2.14				0.19	0.33			
94		14	0.9	0.9	0.45	0.38				0.19	0.17			
95		15	1.3	1.3	0.65	1.06				0.19	0.25			
96		16	5.0	2.5	1.26	4.74				0.19	0.48			
97		17	1.0	1.0	0.50	0.52				0.19	0.19			
98		18	0.2	0.2	0.10	0.00				0.19	0.04			
99		19	0.9	0.9	0.45	0.38				0.19	0.17			
100		20	1.1	1.1	0.55	0.69				0.19	0.21			
101		21	0.4	0.4	0.20	0.03				0.19	0.08			
102		22	0.5	0.5	0.25	0.07				0.19	0.10			
103		23	2.3	1.7	0.86	2.04				0.19	0.33			
104		24	1.0	1.0	0.50	0.52				0.19	0.19			
105		25	0.3	0.3	0.15	0.01				0.19	0.06			
106														
107		1	0.7	0.7	0.35	0.18	19.58			0.19	0.13	0.23	0.16	0.72
108		2	0.9	0.9	0.45	0.38				0.19	0.17			
109		3	1.0	1.0	0.50	0.52				0.19	0.19			
110		4	0.6	0.6	0.30	0.11				0.19	0.11			
111		5	0.8	0.8	0.40	0.27				0.19	0.15			
112		6	1.2	1.2	0.60	0.87				0.19	0.23			
113		7	1.1	1.1	0.55	0.69				0.19	0.21			
114		8	0.7	0.7	0.35	0.18				0.19	0.13			
115		9	10.7	3.7	1.85	10.44				0.19	0.70			
116		10	1.9	1.6	0.78	1.64				0.19	0.30			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
117		11	0.8	0.8	0.40	0.27				0.19	0.15			
118		12	0.7	0.7	0.35	0.18				0.19	0.13			
119		13	0.6	0.6	0.30	0.11				0.19	0.11			
120		14	4.0	2.3	1.13	3.74				0.19	0.43			
121														
122	C21.0	1	0.7	0.7	0.35	0.18	4.14	5.62		0.19	0.13	0.17	0.07	0.44
123		2	0.8	0.8	0.40	0.27				0.19	0.15			
124		3	1.1	1.1	0.55	0.69				0.19	0.21			
125		4	1.4	1.3	0.67	1.14				0.19	0.25			
126		5	0.2	0.2	0.10	0.00				0.19	0.04			
127		6	0.6	0.6	0.30	0.11				0.19	0.11			
128		7	1.1	1.1	0.55	0.69				0.19	0.21			
129		8	1.3	1.3	0.65	1.06				0.19	0.25			
130														
131		1	1.6	1.4	0.71	1.34	7.10			0.19	0.27	0.18	0.08	0.43
132		2	0.2	0.2	0.10	0.00				0.19	0.04			
133		3	1.1	1.1	0.55	0.69				0.19	0.21			
134		4	1.2	1.2	0.60	0.87				0.19	0.23			
135		5	1.0	1.0	0.50	0.52				0.19	0.19			
136		6	0.8	0.8	0.40	0.27				0.19	0.15			
137		7	0.2	0.2	0.10	0.00				0.19	0.04			
138		8	0.9	0.9	0.45	0.38				0.19	0.17			
139		9	0.9	0.9	0.45	0.38				0.19	0.17			
140		10	0.8	0.8	0.40	0.27				0.19	0.15			
141		11	1.5	1.4	0.69	1.24				0.19	0.26			
142		12	1.4	1.3	0.67	1.14				0.19	0.25			
143														
144	C26.4	1	0.5	0.5	0.25	0.07	13.13	14.26		0.19	0.10	0.20	0.15	0.74
145		2	0.9	0.9	0.45	0.38				0.19	0.17			
146		3	0.5	0.5	0.25	0.07				0.19	0.10			
147		4	0.4	0.4	0.20	0.03				0.19	0.08			
148		5	0.9	0.9	0.45	0.38				0.19	0.17			
149		6	1.0	1.0	0.50	0.52				0.19	0.19			
150		7	3.1	2.0	0.99	2.84				0.19	0.38			
151		8	4.7	2.4	1.22	4.44				0.19	0.46			
152		9	4.1	2.3	1.14	3.84				0.19	0.43			
153		10	0.4	0.4	0.20	0.03				0.19	0.08			
154		11	0.2	0.2	0.10	0.00				0.19	0.04			
155		12	1.0	1.0	0.50	0.52				0.19	0.19			
156														
157		1	1.5	1.4	0.69	1.24	15.38			0.19	0.26	0.21	0.10	0.48
158		2	0.6	0.6	0.30	0.11				0.19	0.11			
159		3	0.9	0.9	0.45	0.38				0.19	0.17			
160		4	0.9	0.9	0.45	0.38				0.19	0.17			
161		5	0.5	0.5	0.25	0.07				0.19	0.10			
162		6	1.0	1.0	0.50	0.52				0.19	0.19			
163		7	1.4	1.3	0.67	1.14				0.19	0.25			
164		8	1.2	1.2	0.60	0.87				0.19	0.23			
165		9	1.1	1.1	0.55	0.69				0.19	0.21			
166		10	0.2	0.2	0.10	0.00				0.19	0.04			
167		11	1.0	1.0	0.50	0.52				0.19	0.19			
168		12	3.0	2.0	0.98	2.74				0.19	0.37			
169		13	1.4	1.3	0.67	1.14				0.19	0.25			
170		14	4.4	2.4	1.18	4.14				0.19	0.45			
171		15	0.8	0.8	0.40	0.27				0.19	0.15			
172		16	0.6	0.6	0.30	0.11				0.19	0.11			
173		17	1.3	1.3	0.65	1.06				0.19	0.25			
174														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
175	C29.1	1	0.3	0.3	0.15	0.01	13.88			0.21	0.06	0.16	0.14	0.87
176		2	0.2	0.2	0.10	0.00				0.21	0.04			
177		3	0.4	0.4	0.20	0.03				0.21	0.08			
178		4	0.3	0.3	0.15	0.01				0.21	0.06			
179		5	0.5	0.5	0.25	0.07				0.21	0.11			
180		6	0.2	0.2	0.10	0.00				0.21	0.04			
181		7	0.2	0.2	0.10	0.00				0.21	0.04			
182		8	1.1	1.1	0.55	0.69				0.21	0.23			
183		9	0.9	0.9	0.45	0.38				0.21	0.19			
184		10	2.2	1.7	0.84	1.94				0.21	0.35			
185		11	0.2	0.2	0.10	0.00				0.21	0.04			
186		12	0.9	0.9	0.45	0.38				0.21	0.19			
187		13	0.7	0.7	0.35	0.18				0.21	0.15			
188		14	0.6	0.6	0.30	0.11				0.21	0.13			
189		15	1.3	1.3	0.65	1.06				0.21	0.27			
190		16	7.5	3.1	1.55	7.24				0.21	0.65			
191		17	0.5	0.5	0.25	0.07				0.21	0.11			
192		18	0.6	0.6	0.30	0.11				0.21	0.13			
193		19	0.8	0.8	0.40	0.27				0.21	0.17			
194		20	0.5	0.5	0.25	0.07				0.21	0.11			
195		21	1.5	1.4	0.69	1.24				0.21	0.29			
196														
197	C29.3	1	1.1	1.1	0.55	0.69	17.83			0.25	0.28	0.18	0.15	0.80
198		2	0.4	0.4	0.20	0.03				0.25	0.10			
199		3	3.0	2.0	0.98	2.74				0.25	0.49			
200		4	1.0	1.0	0.50	0.52				0.25	0.25			
201		5	0.2	0.2	0.10	0.00				0.25	0.05			
202		6	0.2	0.2	0.10	0.00				0.25	0.05			
203		7	0.2	0.2	0.10	0.00				0.25	0.05			
204		8	0.2	0.2	0.10	0.00				0.25	0.05			
205		9	1.8	1.5	0.76	1.54				0.25	0.38			
206		10	1.9	1.6	0.78	1.64				0.25	0.39			
207		11	1.7	1.5	0.74	1.44				0.25	0.37			
208		12	1.5	1.4	0.69	1.24				0.25	0.35			
209		13	2.0	1.6	0.80	1.74				0.25	0.40			
210		14	0.2	0.2	0.10	0.00				0.25	0.05			
211		15	0.2	0.2	0.10	0.00				0.25	0.05			
212		16	0.5	0.5	0.25	0.07				0.25	0.13			
213		17	1.6	1.4	0.71	1.34				0.25	0.36			
214		18	3.0	2.0	0.98	2.74				0.25	0.49			
215		19	0.8	0.8	0.40	0.27				0.25	0.20			
216		20	0.4	0.4	0.20	0.03				0.25	0.10			
217		21	0.3	0.3	0.15	0.01				0.25	0.08			
218		22	1.0	1.0	0.50	0.52				0.25	0.25			
219		23	0.2	0.2	0.10	0.00				0.25	0.05			
220		24	0.2	0.2	0.10	0.00				0.25	0.05			
221		25	0.1	0.1	0.05	0.00				0.25	0.03			
222		26	0.2	0.2	0.10	0.00				0.25	0.05			
223		27	0.9	0.9	0.45	0.38				0.25	0.23			
224		28	0.5	0.5	0.25	0.07				0.25	0.13			
225		29	0.3	0.3	0.15	0.01				0.25	0.08			
226		30	1.0	1.0	0.50	0.52				0.25	0.25			
227		31	0.2	0.2	0.10	0.00				0.25	0.05			
228		32	0.5	0.5	0.25	0.07				0.25	0.13			
229		33	0.7	0.7	0.35	0.18				0.25	0.18			
230		34	0.2	0.2	0.10	0.00				0.25	0.05			
231														
232	C40.5	1	0.2	0.2	0.10	0.00	9.27	13.23		0.19	0.04	0.15	0.09	0.59

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
233		2	0.8	0.8	0.40	0.27				0.19	0.15			
234		3	0.7	0.7	0.35	0.18				0.19	0.13			
235		4	0.9	0.9	0.45	0.38				0.19	0.17			
236		5	2.0	1.6	0.80	1.74				0.19	0.30			
237		6	0.3	0.3	0.15	0.01				0.19	0.06			
238		7	1.2	1.2	0.60	0.87				0.19	0.23			
239		8	2.8	1.9	0.94	2.54				0.19	0.36			
240		9	1.9	1.6	0.78	1.64				0.19	0.30			
241		10	0.9	0.9	0.45	0.38				0.19	0.17			
242		11	0.6	0.6	0.30	0.11				0.19	0.11			
243		12	0.7	0.7	0.35	0.18				0.19	0.13			
244		13	1.0	1.0	0.50	0.52				0.19	0.19			
245		14	0.5	0.5	0.25	0.07				0.19	0.10			
246		15	0.4	0.4	0.20	0.03				0.19	0.08			
247		16	0.6	0.6	0.30	0.11				0.19	0.11			
248		17	0.5	0.5	0.25	0.07				0.19	0.10			
249		18	0.4	0.4	0.20	0.03				0.19	0.08			
250		19	0.6	0.6	0.30	0.11				0.19	0.11			
251		20	0.3	0.3	0.15	0.01				0.19	0.06			
252														
253		1	0.5	0.5	0.25	0.07	17.19			0.19	0.10	0.19	0.20	1.05
254		2	0.2	0.2	0.10	0.00				0.19	0.04			
255		3	0.8	0.8	0.40	0.27				0.19	0.15			
256		4	0.3	0.3	0.15	0.01				0.19	0.06			
257		5	1.5	1.4	0.69	1.24				0.19	0.26			
258		6	12.3	4.0	1.98	12.04				0.19	0.75			
259		7	0.5	0.5	0.25	0.07				0.19	0.10			
260		8	0.4	0.4	0.20	0.03				0.19	0.08			
261		9	1.8	1.5	0.76	1.54				0.19	0.29			
262		10	0.2	0.2	0.10	0.00				0.19	0.04			
263		11	0.7	0.7	0.35	0.18				0.19	0.13			
264		12	2.0	1.6	0.80	1.74				0.19	0.30			
265														
266	C40.7	1	6.0	2.8	1.38	5.74	12.55	8.46		0.19	0.53	0.21	0.13	0.64
267		2	1.7	1.5	0.74	1.44				0.19	0.28			
268		3	0.4	0.4	0.20	0.03				0.19	0.08			
269		4	1.0	1.0	0.50	0.52				0.19	0.19			
270		5	2.3	1.7	0.86	2.04				0.19	0.33			
271		6	0.6	0.6	0.30	0.11				0.19	0.11			
272		7	1.1	1.1	0.55	0.69				0.19	0.21			
273		8	1.0	1.0	0.50	0.52				0.19	0.19			
274		9	0.6	0.6	0.30	0.11				0.19	0.11			
275		10	1.3	1.3	0.65	1.06				0.19	0.25			
276		11	0.8	0.8	0.40	0.27				0.19	0.15			
277		12	0.2	0.2	0.10	0.00				0.19	0.04			
278														
279		1	1.2	1.2	0.60	0.87	4.38			0.19	0.23	0.17	0.07	0.57
280		2	1.5	1.4	0.69	1.24				0.19	0.26			
281		3	0.6	0.6	0.30	0.11				0.19	0.11			
282		4	1.3	1.3	0.65	1.06				0.19	0.25			
283		5	0.3	0.3	0.15	0.01				0.19	0.06			
284		6	0.6	0.6	0.30	0.11				0.19	0.11			
285		7	1.0	1.0	0.50	0.52				0.19	0.19			
286		8	0.8	0.8	0.40	0.27				0.19	0.15			
287		9	0.7	0.7	0.35	0.18				0.19	0.13			
288														
289	C40.8	1	0.5	0.5	0.25	0.07	10.59			0.19	0.10	0.16	0.09	0.58
290		2	1.5	1.4	0.69	1.24				0.19	0.26			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
291		3	0.2	0.2	0.10	0.00				0.19	0.04			
292		4	0.2	0.2	0.10	0.00				0.19	0.04			
293		5	3.0	2.0	0.98	2.74				0.19	0.37			
294		6	0.2	0.2	0.10	0.00				0.19	0.04			
295		7	0.7	0.7	0.35	0.18				0.19	0.13			
296		8	0.9	0.9	0.45	0.38				0.19	0.17			
297		9	1.3	1.3	0.65	1.06				0.19	0.25			
298		10	1.2	1.2	0.60	0.87				0.19	0.23			
299		11	0.6	0.6	0.30	0.11				0.19	0.11			
300		12	0.9	0.9	0.45	0.38				0.19	0.17			
301		13	1.0	1.0	0.50	0.52				0.19	0.19			
302		14	0.8	0.8	0.40	0.27				0.19	0.15			
303		15	0.8	0.8	0.40	0.27				0.19	0.15			
304		16	0.6	0.6	0.30	0.11				0.19	0.11			
305		17	1.5	1.4	0.69	1.24				0.19	0.26			
306		18	1.3	1.3	0.65	1.06				0.19	0.25			
307		19	0.5	0.5	0.25	0.07				0.19	0.10			
308		20	0.2	0.2	0.10	0.00				0.19	0.04			
309														
310	C57.9	1	5.0	2.5	1.26	4.74	4.92	3.57		0.19	0.48	0.18	0.21	1.16
311		2	0.5	0.5	0.25	0.07				0.19	0.10			
312		3	0.1	0.1	0.05	0.00				0.19	0.02			
313		4	0.6	0.6	0.30	0.11				0.19	0.11			
314														
315		1	0.7	0.7	0.35	0.18	2.22			0.19	0.13	0.15	0.09	0.62
316		2	1.8	1.5	0.76	1.54				0.19	0.29			
317		3	0.6	0.6	0.30	0.11				0.19	0.11			
318		4	0.9	0.9	0.45	0.38				0.19	0.17			
319		5	0.2	0.2	0.10	0.00				0.19	0.04			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Appendix 1c: Volumetric pellet data for TACTS borehole E													
2														
3														
4	Sample #	Grain No.	MGU	D	R	V	T. V.	AVV		MF	TGD	Mean TGD	ST DEV	CV
5														
6	E17.7	1	1.0	1.0	0.50	0.52	1.59	1.20		0.30	0.30	0.169	0.11	0.64
7		2	0.2	0.2	0.10	0.00				0.30	0.06			
8		3	0.9	0.9	0.45	0.38				0.30	0.27			
9		4	0.2	0.2	0.10	0.00				0.30	0.06			
10		5	0.6	0.6	0.30	0.11				0.30	0.18			
11		6	0.2	0.2	0.10	0.00				0.30	0.06			
12		7	0.4	0.4	0.20	0.03				0.30	0.12			
13		8	1.0	1.0	0.50	0.52				0.30	0.30			
14														
15		1	1.0	1.0	0.50	0.52	0.82			0.30	0.30	0.125	0.06	0.51
16		2	0.3	0.3	0.15	0.01				0.30	0.09			
17		3	0.4	0.4	0.20	0.03				0.30	0.12			
18		4	0.3	0.3	0.15	0.01				0.30	0.09			
19		5	0.2	0.2	0.10	0.00				0.30	0.06			
20		6	0.5	0.5	0.25	0.07				0.30	0.15			
21		7	0.4	0.4	0.20	0.03				0.30	0.12			
22		8	0.5	0.5	0.25	0.07				0.30	0.15			
23		9	0.3	0.3	0.15	0.01				0.30	0.09			
24		10	0.3	0.3	0.15	0.01				0.30	0.09			
25		11	0.4	0.4	0.20	0.03				0.30	0.12			
26														
27	E23.5	1	0.9	0.9	0.45	0.38	1.77	2.11		0.25	0.23	0.111	0.08	0.68
28		2	0.2	0.2	0.10	0.00				0.25	0.05			
29		3	0.6	0.6	0.30	0.11				0.25	0.15			
30		4	0.6	0.6	0.30	0.11				0.25	0.15			
31		5	0.4	0.4	0.20	0.03				0.25	0.10			
32		6	0.2	0.2	0.10	0.00				0.25	0.05			
33		7	1.0	1.0	0.50	0.52				0.25	0.25			
34		8	0.1	0.1	0.05	0.00				0.25	0.03			
35		9	0.6	0.6	0.30	0.11				0.25	0.15			
36		10	0.3	0.3	0.15	0.01				0.25	0.08			
37		11	0.3	0.3	0.15	0.01				0.25	0.08			
38		12	0.1	0.1	0.05	0.00				0.25	0.03			
39		13	0.8	0.8	0.40	0.27				0.25	0.20			
40		14	0.1	0.1	0.05	0.00				0.25	0.03			
41		15	0.2	0.2	0.10	0.00				0.25	0.05			
42		16	0.7	0.7	0.35	0.18				0.25	0.18			
43														
44		1	0.4	0.4	0.20	0.03	2.46			0.25	0.10	0.109	0.10	0.93
45		2	0.8	0.8	0.40	0.27				0.25	0.20			
46		3	2.0	1.6	0.80	1.74				0.25	0.40			
47		4	0.1	0.1	0.05	0.00				0.25	0.03			
48		5	0.3	0.3	0.15	0.01				0.25	0.08			
49		6	0.8	0.8	0.40	0.27				0.25	0.20			
50		7	0.5	0.5	0.25	0.07				0.25	0.13			
51		8	0.3	0.3	0.15	0.01				0.25	0.08			
52		9	0.3	0.3	0.15	0.01				0.25	0.08			
53		10	0.1	0.1	0.05	0.00				0.25	0.03			
54		11	0.4	0.4	0.20	0.03				0.25	0.10			
55		12	0.2	0.2	0.10	0.00				0.25	0.05			
56		13	0.2	0.2	0.10	0.00				0.25	0.05			
57		14	0.1	0.1	0.05	0.00				0.25	0.03			
58														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
59	E29.4	1	0.5	0.5	0.25	0.07	1.84	8.70		0.19	0.10	0.133	0.04	0.32
60		2	1.0	1.0	0.50	0.52				0.19	0.19			
61		3	1.0	1.0	0.50	0.52				0.19	0.19			
62		4	0.7	0.7	0.35	0.18				0.19	0.13			
63		5	0.4	0.4	0.20	0.03				0.19	0.08			
64		6	0.7	0.7	0.35	0.18				0.19	0.13			
65		7	0.5	0.5	0.25	0.07				0.19	0.10			
66		8	0.8	0.8	0.40	0.27				0.19	0.15			
67											0.00			
68		1	0.7	0.7	0.35	0.18	15.56			0.19	0.13	0.124	0.13	1.05
69		2	0.6	0.6	0.30	0.11				0.19	0.11			
70		3	0.4	0.4	0.20	0.03				0.19	0.08			
71		4	0.4	0.4	0.20	0.03				0.19	0.08			
72		5	1.0	1.0	0.50	0.52				0.19	0.19			
73		6	0.3	0.3	0.15	0.01				0.19	0.06			
74		7	0.4	0.4	0.20	0.03				0.19	0.08			
75		8	0.4	0.4	0.20	0.03				0.19	0.08			
76		9	0.8	0.8	0.40	0.27				0.19	0.15			
77		10	0.3	0.3	0.15	0.01				0.19	0.06			
78		11	0.4	0.4	0.20	0.03				0.19	0.08			
79		12	0.6	0.6	0.30	0.11				0.19	0.11			
80		13	0.1	0.1	0.05	0.00				0.19	0.02			
81		14	3.0	3.0	1.50	14.13				0.19	0.57			
82		15	0.4	0.4	0.20	0.03				0.19	0.08			
83											0.00			
84	E35.7	1	0.7	0.7	0.35	0.18	0.33	0.47		0.12	0.08	0.043	0.03	0.60
85		2	0.5	0.5	0.25	0.07				0.12	0.06			
86		3	0.2	0.2	0.10	0.00				0.12	0.02			
87		4	0.3	0.3	0.15	0.01				0.12	0.04			
88		5	0.1	0.1	0.05	0.00				0.12	0.01			
89		6	0.2	0.2	0.10	0.00				0.12	0.02			
90		7	0.5	0.5	0.25	0.07				0.12	0.06			
91											0.00			
92		1	0.6	0.6	0.30	0.11	0.60			0.12	0.07	0.062	0.03	0.50
93		2	0.9	0.9	0.45	0.38				0.12	0.11			
94		3	0.2	0.2	0.10	0.00				0.12	0.02			
95		4	0.4	0.4	0.20	0.03				0.12	0.05			
96		5	0.5	0.5	0.25	0.07				0.12	0.06			
97											0.00			
98	E57.8	1	1.0	1.0	0.50	0.52	3.85	2.92		0.25	0.25	0.171	0.09	0.50
99		2	0.3	0.3	0.15	0.01				0.25	0.08			
100		3	1.0	1.0	0.50	0.52				0.25	0.25			
101		4	1.0	1.0	0.50	0.52				0.25	0.25			
102		5	0.2	0.2	0.10	0.00				0.25	0.05			
103		6	0.7	0.7	0.35	0.18				0.25	0.18			
104		7	0.8	0.8	0.40	0.27				0.25	0.20			
105		8	0.6	0.6	0.30	0.11				0.25	0.15			
106		9	1.0	1.0	0.50	0.52				0.25	0.25			
107		10	0.2	0.2	0.10	0.00				0.25	0.05			
108		11	0.1	0.1	0.05	0.00				0.25	0.03			
109		12	0.9	0.9	0.45	0.38				0.25	0.23			
110		13	0.8	0.8	0.40	0.27				0.25	0.20			
111		14	1.0	1.0	0.50	0.52				0.25	0.25			
112											0.00			
113		1	1.0	1.0	0.50	0.52	1.98			0.25	0.25	0.193	0.05	0.27
114		2	0.8	0.8	0.40	0.27				0.25	0.20			
115		3	0.8	0.8	0.40	0.27				0.25	0.20			
116		4	0.5	0.5	0.25	0.07				0.25	0.13			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
117		5	0.8	0.8	0.40	0.27				0.25	0.20			
118		6	1.0	1.0	0.50	0.52				0.25	0.25			
119		7	0.5	0.5	0.25	0.07				0.25	0.13			
120											0.00			
121	E57.9	1	0.3	0.3	0.15	0.01	2.61	2.36		0.21	0.06	0.117	0.12	1.04
122		2	0.2	0.2	0.10	0.00				0.21	0.04			
123		3	1.6	1.4	0.71	1.34				0.21	0.30			
124		4	0.2	0.2	0.10	0.00				0.21	0.04			
125		5	0.2	0.2	0.10	0.00				0.21	0.04			
126		6	1.5	1.4	0.69	1.24				0.21	0.29			
127		7	0.2	0.2	0.10	0.00				0.21	0.04			
128											0.00			
129		1	0.2	0.2	0.10	0.00	2.11			0.21	0.04	0.154	0.08	0.55
130		2	0.5	0.5	0.25	0.07				0.21	0.11			
131		3	0.6	0.6	0.30	0.11				0.21	0.13			
132		4	1.1	1.1	0.55	0.69				0.21	0.23			
133		5	1.3	1.3	0.65	1.06				0.21	0.27			
134		6	0.7	0.7	0.35	0.18				0.21	0.15			
135											0.00			
136	E60.8	1	0.3	0.3	0.15	0.01	6.90	5.09		0.17	0.05	0.108	0.05	0.43
137		2	1.0	1.0	0.50	0.52				0.17	0.17			
138		3	1.0	1.0	0.50	0.52				0.17	0.17			
139		4	0.4	0.4	0.20	0.03				0.17	0.07			
140		5	0.6	0.6	0.30	0.11				0.17	0.10			
141		6	0.4	0.4	0.20	0.03				0.17	0.07			
142		7	0.8	0.8	0.40	0.27				0.17	0.14			
143		8	0.5	0.5	0.25	0.07				0.17	0.09			
144		9	0.4	0.4	0.20	0.03				0.17	0.07			
145		10	1.0	1.0	0.50	0.52				0.17	0.17			
146		11	1.0	1.0	0.50	0.52				0.17	0.17			
147		12	0.8	0.8	0.40	0.27				0.17	0.14			
148		13	0.4	0.4	0.20	0.03				0.17	0.07			
149		14	0.6	0.6	0.30	0.11				0.17	0.10			
150		15	0.2	0.2	0.10	0.00				0.17	0.03			
151		16	0.6	0.6	0.30	0.11				0.17	0.10			
152		17	0.3	0.3	0.15	0.01				0.17	0.05			
153		18	1.0	1.0	0.50	0.52				0.17	0.17			
154		19	1.0	1.0	0.50	0.52				0.17	0.17			
155		20	0.4	0.4	0.20	0.03				0.17	0.07			
156		21	0.6	0.6	0.30	0.11				0.17	0.10			
157		22	0.4	0.4	0.20	0.03				0.17	0.07			
158		23	0.8	0.8	0.40	0.27				0.17	0.14			
159		24	0.5	0.5	0.25	0.07				0.17	0.09			
160		25	0.4	0.4	0.20	0.03				0.17	0.07			
161		26	1.0	1.0	0.50	0.52				0.17	0.17			
162		27	1.0	1.0	0.50	0.52				0.17	0.17			
163		28	1.0	1.0	0.50	0.52				0.17	0.17			
164		29	0.8	0.8	0.40	0.27				0.17	0.14			
165		30	0.4	0.4	0.20	0.03				0.17	0.07			
166		31	0.6	0.6	0.30	0.11				0.17	0.10			
167		32	0.2	0.2	0.10	0.00				0.17	0.03			
168		33	0.6	0.6	0.30	0.11				0.17	0.10			
169											0.00			
170		1	1.0	1.0	0.50	0.52	3.28			0.17	0.17	0.104	0.06	0.54
171		2	0.2	0.2	0.10	0.00				0.17	0.03			
172		3	0.2	0.2	0.10	0.00				0.17	0.03			
173		4	1.0	1.0	0.50	0.52				0.17	0.17			
174		5	0.6	0.6	0.30	0.11				0.17	0.10			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
175		6	1.0	1.0	0.50	0.52				0.17	0.17			
176		7	0.5	0.5	0.25	0.07				0.17	0.09			
177		8	1.0	1.0	0.50	0.52				0.17	0.17			
178		9	0.6	0.6	0.30	0.11				0.17	0.10			
179		10	1.0	1.0	0.50	0.52				0.17	0.17			
180		11	0.5	0.5	0.25	0.07				0.17	0.09			
181		12	0.3	0.3	0.15	0.01				0.17	0.05			
182		13	0.3	0.3	0.15	0.01				0.17	0.05			
183		14	0.2	0.2	0.10	0.00				0.17	0.03			
184		15	0.8	0.8	0.40	0.27				0.17	0.14			
185											0.00			
186	E61.0	1	0.5	0.5	0.25	0.07	10.19			0.12	0.06	0.106	0.07	0.66
187		2	1.2	1.2	0.60	0.87				0.12	0.14			
188		3	5.0	2.5	1.26	4.74				0.12	0.30			
189		4	0.9	0.9	0.45	0.38				0.12	0.11			
190		5	1.0	1.0	0.50	0.52				0.12	0.12			
191		6	1.5	1.4	0.69	1.24				0.12	0.17			
192		7	0.3	0.3	0.15	0.01				0.12	0.04			
193		8	1.2	1.2	0.60	0.87				0.12	0.14			
194		9	0.3	0.3	0.15	0.01				0.12	0.04			
195		10	0.6	0.6	0.30	0.11				0.12	0.07			
196		11	1.2	1.2	0.60	0.87				0.12	0.14			
197		12	0.8	0.8	0.40	0.27				0.12	0.10			
198		13	0.7	0.7	0.35	0.18				0.12	0.08			
199		14	0.4	0.4	0.20	0.03				0.12	0.05			
200		15	0.3	0.3	0.15	0.01				0.12	0.04			
201											0.00			
202	E91.6	1	1.0	1.0	0.50	0.52	1.84	1.49		0.25	0.25	0.238	0.03	0.11
203		2	1.0	1.0	0.50	0.52				0.25	0.25			
204		3	1.0	1.0	0.50	0.52				0.25	0.25			
205		4	0.8	0.8	0.40	0.27				0.25	0.20			
206											0.00			
207		1	1.0	1.0	0.50	0.52	1.14			0.25	0.25	0.167	0.05	0.29
208		2	0.6	0.6	0.30	0.11				0.25	0.15			
209		3	0.4	0.4	0.20	0.03				0.25	0.10			
210		4	0.7	0.7	0.35	0.18				0.25	0.18			
211		5	0.6	0.6	0.30	0.11				0.25	0.15			
212		6	0.7	0.7	0.35	0.18				0.25	0.18			

Appendix 1d: Volumetric pellet data for TACTS borehole F.

Sample #	Grain No.	MGU	D	R	V	Tot. Vol	AVV	MF	TGD	Mean TGD	STDEV	CV
F0.1	1	1.0	1.0	0.50	0.52	0.52	0.64	0.12	0.12	0.120		
	1	0.9	0.9	0.45	0.38	0.76		0.12	0.11	0.108	0.00	0.00
	2	0.9	0.9	0.45	0.38			0.12	0.11			
F3.4	1	1.0	1.0	0.50	0.52	1.60	0.91	0.30	0.30	0.240	0.12	0.51
	2	0.2	0.2	0.10	0.00			0.30	0.06			
	3	0.9	0.9	0.45	0.38			0.30	0.27			
	4	1.1	1.1	0.55	0.69			0.30	0.33			
	1	1.0	1.0	0.50	0.52	0.56		0.30	0.30	0.120	0.13	1.06
	2	0.1	0.1	0.05	0.00			0.30	0.03			
	3	0.4	0.4	0.20	0.03			0.30	0.12			
	4	0.1	0.1	0.05	0.00			0.30	0.03			
	1	1.0	1.0	0.50	0.52	0.56		0.30	0.30	0.128	0.12	0.95
	2	0.4	0.4	0.20	0.03			0.30	0.12			
	3	0.1	0.1	0.05	0.00			0.30	0.03			
	4	0.2	0.2	0.10	0.00			0.30	0.06			
F5.9	1	1.3	1.3	0.65	1.06	1.45	0.93	0.68	0.88	0.612	0.25	0.40
	2	0.6	0.6	0.30	0.11			0.68	0.41			
	3	0.8	0.8	0.40	0.27			0.68	0.54			
	1	0.9	0.9	0.45	0.38	0.41		0.68	0.61	0.170	0.19	1.09
	2	0.3	0.3	0.15	0.01			0.68	0.20			
	3	0.2	0.2	0.10	0.00			0.68	0.14			
	4	0.1	0.1	0.05	0.00			0.68	0.07			
	5	0.1	0.1	0.05	0.00			0.68	0.07			
	6	0.1	0.1	0.05	0.00			0.68	0.07			
	7	0.2	0.2	0.10	0.00			0.68	0.14			
	8	0.1	0.1	0.05	0.00			0.68	0.07			
F6.7	1	0.9	0.9	0.45	0.38	0.38	0.62	0.25	0.23	0.225		
	1	1.1	1.1	0.55	0.69	0.85		0.25	0.28	0.125	0.10	0.76
	2	0.4	0.4	0.20	0.03			0.25	0.10			
	3	0.1	0.1	0.05	0.00			0.25	0.03			
	4	0.6	0.6	0.30	0.11			0.25	0.15			
	5	0.3	0.3	0.15	0.01			0.25	0.08			
F8.0	1	0.9	0.9	0.45	0.38	1.17	1.32	0.25	0.23	0.225	0.03	0.11
	2	1.0	1.0	0.50	0.52			0.25	0.25			
	3	0.8	0.8	0.40	0.27			0.25	0.20			
	1	1.0	1.0	0.50	0.52	0.91		0.25	0.25	0.238	0.02	0.07
	2	0.9	0.9	0.45	0.38			0.25	0.23			
F10.1	1	1.3	1.3	0.65	1.06	1.46	2.13	0.19	0.25	0.158	0.10	0.60
	2	0.3	0.3	0.15	0.01			0.19	0.06			
	3	0.9	0.9	0.45	0.38			0.19	0.17			
	1	2.2	1.7	0.84	1.94	2.80		0.19	0.32	0.158	0.08	0.53

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
59		2	0.8	0.8	0.40	0.27				0.19	0.15			
60		3	0.6	0.6	0.30	0.11				0.19	0.11			
61		4	0.4	0.4	0.20	0.03				0.19	0.08			
62		5	0.8	0.8	0.40	0.27				0.19	0.15			
63		6	0.7	0.7	0.35	0.18				0.19	0.13			
64														
65	F12.0	1	0.9	0.9	0.45	0.38	0.40	0.56		0.25	0.23	0.150	0.11	0.71
66		2	0.3	0.3	0.15	0.01				0.25	0.08			
67														
68		1	0.9	0.9	0.45	0.38	0.72			0.25	0.23	0.183	0.05	0.28
69		2	0.8	0.8	0.40	0.27				0.25	0.20			
70		3	0.5	0.5	0.25	0.07				0.25	0.13			
71														
72	F12.2	1	0.8	0.8	0.40	0.27	0.45	0.39		0.33	0.26	0.145	0.10	0.65
73		2	0.6	0.6	0.30	0.11				0.33	0.20			
74		3	0.2	0.2	0.10	0.00				0.33	0.07			
75		4	0.1	0.1	0.05	0.00				0.33	0.03			
76		5	0.5	0.5	0.25	0.07				0.33	0.17			
77														
78		1	0.7	0.7	0.35	0.18	0.33			0.33	0.23	0.139	0.08	0.54
79		2	0.2	0.2	0.10	0.00				0.33	0.07			
80		3	0.6	0.6	0.30	0.11				0.33	0.20			
81		4	0.2	0.2	0.10	0.00				0.33	0.07			
82		5	0.4	0.4	0.20	0.03				0.33	0.13			
83														
84	F18.9	1	0.9	0.9	0.45	0.38	0.38	0.25		0.12	0.11	0.108		
85														
86		1	0.7	0.7	0.35	0.18	0.11			0.12	0.08	0.060	0.03	0.55
87		2	0.8	0.8	0.40	0.27				0.12	0.10			
88		3	0.4	0.4	0.20	0.03				0.12	0.05			
89		4	0.1	0.1	0.05	0.00				0.12	0.01			
90		5	0.5	0.5	0.25	0.07				0.12	0.06			
91														
92	F20.6	1	0.8	0.8	0.40	0.27	0.27	0.27		0.12	0.10	0.060	0.05	0.85
93		2	0.2	0.2	0.10	0.00				0.12	0.02			
94														
95		1	0.5	0.5	0.25	0.07	0.26			0.12	0.06	0.051	0.03	0.52
96		2	0.3	0.3	0.15	0.01				0.12	0.04			
97		3	0.2	0.2	0.10	0.00				0.12	0.02			
98		4	0.7	0.7	0.35	0.18				0.12	0.08			
99														
100	F23.8	1	1.0	1.0	0.50	0.52	1.79	1.78		0.12	0.12	0.084	0.04	0.42
101		2	0.9	0.9	0.45	0.38				0.12	0.11			
102		3	0.6	0.6	0.30	0.11				0.12	0.07			
103		4	0.5	0.5	0.25	0.07				0.12	0.06			
104		5	0.2	0.2	0.10	0.00				0.12	0.02			
105		6	1.0	1.0	0.50	0.52				0.12	0.12			
106		7	0.7	0.7	0.35	0.18				0.12	0.08			
107														
108		1	1.2	1.2	0.60	0.87	1.77			0.12	0.14	0.084	0.04	0.51
109		2	1.0	1.0	0.50	0.52				0.12	0.12			
110		3	0.4	0.4	0.20	0.03				0.12	0.05			
111		4	0.3	0.3	0.15	0.01				0.12	0.04			
112		5	0.5	0.5	0.25	0.07				0.12	0.06			
113		6	0.8	0.8	0.40	0.27				0.12	0.10			
114														
115	F23.9	1	1.1	1.1	0.55	0.69	1.62	1.40		0.12	0.13	0.112	0.05	0.41
116		2	1.2	1.2	0.60	0.87				0.12	0.14			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
117		3	0.5	0.5	0.25	0.07				0.12	0.06			
118														
119		1	1.0	1.0	0.50	0.52	1.17			0.12	0.12	0.108	0.01	0.11
120		2	0.8	0.8	0.40	0.27				0.12	0.10			
121		3	0.9	0.9	0.45	0.38				0.12	0.11			
122														
123	F27.0	1	1.3	1.3	0.65	1.06	8.89	6.28		0.12	0.16	0.085	0.07	0.80
124		2	2.2	1.7	0.84	1.94				0.12	0.20			
125		3	0.2	0.2	0.10	0.00				0.12	0.02			
126		4	0.2	0.2	0.10	0.00				0.12	0.02			
127		5	0.6	0.6	0.30	0.11				0.12	0.07			
128		6	1.5	1.4	0.69	1.24				0.12	0.17			
129		7	0.2	0.2	0.10	0.00				0.12	0.02			
130		8	0.5	0.5	0.25	0.07				0.12	0.06			
131		9	0.3	0.3	0.15	0.01				0.12	0.04			
132		10	1.3	1.3	0.65	1.06				0.12	0.16			
133		11	2.2	1.7	0.84	1.94				0.12	0.20			
134		12	0.2	0.2	0.10	0.00				0.12	0.02			
135		13	0.2	0.2	0.10	0.00				0.12	0.02			
136		14	0.6	0.6	0.30	0.11				0.12	0.07			
137		15	1.5	1.4	0.69	1.24				0.12	0.17			
138		16	0.2	0.2	0.10	0.00				0.12	0.02			
139		17	0.5	0.5	0.25	0.07				0.12	0.06			
140		18	0.3	0.3	0.15	0.01				0.12	0.04			
141														
142		1	1.1	1.1	0.55	0.69	3.66			0.12	0.13	0.094	0.06	0.62
143		2	1.0	1.0	0.50	0.52				0.12	0.12			
144		3	0.2	0.2	0.10	0.00				0.12	0.02			
145		4	0.9	0.9	0.45	0.38				0.12	0.11			
146		5	0.4	0.4	0.20	0.03				0.12	0.05			
147		6	2.1	1.6	0.82	1.84				0.12	0.20			
148		7	0.3	0.3	0.15	0.01				0.12	0.04			
149		8	0.7	0.7	0.35	0.18				0.12	0.08			
150														
151	F48.8	1	0.6	0.6	0.30	0.11	1.93	4.81		0.25	0.15	0.164	0.07	0.43
152		2	0.8	0.8	0.40	0.27				0.25	0.20			
153		3	1.0	1.0	0.50	0.52				0.25	0.25			
154		4	0.3	0.3	0.15	0.01				0.25	0.08			
155		5	0.2	0.2	0.10	0.00				0.25	0.05			
156		6	0.9	0.9	0.45	0.38				0.25	0.23			
157		7	0.7	0.7	0.35	0.18				0.25	0.18			
158		8	0.9	0.9	0.45	0.38				0.25	0.23			
159		9	0.5	0.5	0.25	0.07				0.25	0.13			
160														
161		1	2.2	1.7	0.84	1.94	7.69			0.25	0.42	0.171	0.17	1.02
162		2	0.9	0.9	0.45	0.38				0.25	0.23			
163		3	0.2	0.2	0.10	0.00				0.25	0.05			
164		4	0.4	0.4	0.20	0.03				0.25	0.10			
165		5	0.8	0.8	0.40	0.27				0.25	0.20			
166		6	0.2	0.2	0.10	0.00				0.25	0.05			
167		7	0.3	0.3	0.15	0.01				0.25	0.08			
168		8	0.1	0.1	0.05	0.00				0.25	0.03			
169		9	0.2	0.2	0.10	0.00				0.25	0.05			
170		10	0.7	0.7	0.35	0.18				0.25	0.18			
171		11	0.6	0.6	0.30	0.11				0.25	0.15			
172		12	5.0	2.5	1.26	4.74				0.25	0.63			
173		13	0.3	0.3	0.15	0.01				0.25	0.08			
174														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
175	F48.9	1	1.3	1.3	0.65	1.06	2.04	4.03		0.19	0.25	0.109	0.08	0.77
176		2	1.0	1.0	0.50	0.52				0.19	0.19			
177		3	0.1	0.1	0.05	0.00				0.19	0.02			
178		4	0.6	0.6	0.30	0.11				0.19	0.11			
179		5	0.1	0.1	0.05	0.00				0.19	0.02			
180		6	0.2	0.2	0.10	0.00				0.19	0.04			
181		7	0.8	0.8	0.40	0.27				0.19	0.15			
182		8	0.5	0.5	0.25	0.07				0.19	0.10			
183														
184		1	3.4	2.1	1.04	3.14	6.01			0.19	0.40	0.192	0.10	0.50
185		2	1.2	1.2	0.60	0.87				0.19	0.23			
186		3	1.0	1.0	0.50	0.52				0.19	0.19			
187		4	0.9	0.9	0.45	0.38				0.19	0.17			
188		5	1.1	1.1	0.55	0.69				0.19	0.21			
189		6	0.8	0.8	0.40	0.27				0.19	0.15			
190		7	0.6	0.6	0.30	0.11				0.19	0.11			
191		8	0.4	0.4	0.20	0.03				0.19	0.08			
192														
193	F49.1	1	1.0	1.0	0.50	0.52	1.20	2.33		0.21	0.21	0.129	0.05	0.39
194		2	0.6	0.6	0.30	0.11				0.21	0.13			
195		3	0.7	0.7	0.35	0.18				0.21	0.15			
196		4	0.5	0.5	0.25	0.07				0.21	0.11			
197		5	0.4	0.4	0.20	0.03				0.21	0.08			
198		6	0.8	0.8	0.40	0.27				0.21	0.17			
199		7	0.3	0.3	0.15	0.01				0.21	0.06			
200														
201		1	2.8	1.9	0.94	2.54	3.47			0.21	0.40	0.159	0.12	0.74
202		2	0.9	0.9	0.45	0.38				0.21	0.19			
203		3	0.5	0.5	0.25	0.07				0.21	0.11			
204		4	0.4	0.4	0.20	0.03				0.21	0.08			
205		5	0.9	0.9	0.45	0.38				0.21	0.19			
206		6	0.2	0.2	0.10	0.00				0.21	0.04			
207		7	0.5	0.5	0.25	0.07				0.21	0.11			
208														
209	F52.0	1	1.0	1.0	0.50	0.52	2.08	3.32		0.19	0.19	0.139	0.08	0.56
210		2	0.9	0.9	0.45	0.38				0.19	0.17			
211		3	0.1	0.1	0.05	0.00				0.19	0.02			
212		4	0.4	0.4	0.20	0.03				0.19	0.08			
213		5	1.2	1.2	0.60	0.87				0.19	0.23			
214		6	0.8	0.8	0.40	0.27				0.19	0.15			
215														
216		1	3.5	2.1	1.06	3.24	4.57			0.19	0.40	0.140	0.11	0.81
217		2	0.8	0.8	0.40	0.27				0.19	0.15			
218		3	0.1	0.1	0.05	0.00				0.19	0.02			
219		4	0.7	0.7	0.35	0.18				0.19	0.13			
220		5	0.1	0.1	0.05	0.00				0.19	0.02			
221		6	0.6	0.6	0.30	0.11				0.19	0.11			
222		7	0.7	0.7	0.35	0.18				0.19	0.13			
223		8	0.5	0.5	0.25	0.07				0.19	0.10			
224		9	1.0	1.0	0.50	0.52				0.19	0.19			
225														
226	F52.1	1	1.3	1.3	0.65	1.06	3.11	4.07		0.12	0.16	0.104	0.03	0.26
227		2	0.9	0.9	0.45	0.38				0.12	0.11			
228		3	0.8	0.8	0.40	0.27				0.12	0.10			
229		4	0.6	0.6	0.30	0.11				0.12	0.07			
230		5	1.0	1.0	0.50	0.52				0.12	0.12			
231		6	0.8	0.8	0.40	0.27				0.12	0.10			
232		7	0.9	0.9	0.45	0.38				0.12	0.11			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
233		8	0.6	0.6	0.30	0.11				0.12	0.07			
234														
235		1	2.3	1.7	0.86	2.04	5.02			0.12	0.21	0.130	0.06	0.44
236		2	1.5	1.4	0.69	1.24				0.12	0.17			
237		3	0.4	0.4	0.20	0.03				0.12	0.05			
238		4	0.8	0.8	0.40	0.27				0.12	0.10			
239		5	0.9	0.9	0.45	0.38				0.12	0.11			
240		6	1.3	1.3	0.65	1.06				0.12	0.16			
241														
242	F55.0	1	4.0	2.3	1.13	3.74	10.49	9.33		0.33	0.74	0.170	0.17	1.01
243		2	0.9	0.9	0.45	0.38				0.33	0.30			
244		3	0.9	0.9	0.45	0.38				0.33	0.30			
245		4	0.7	0.7	0.35	0.18				0.33	0.23			
246		5	0.2	0.2	0.10	0.00				0.33	0.07			
247		6	0.1	0.1	0.05	0.00				0.33	0.03			
248		7	0.2	0.2	0.10	0.00				0.33	0.07			
249		8	0.4	0.4	0.20	0.03				0.33	0.13			
250		9	0.9	0.9	0.45	0.38				0.33	0.30			
251		10	0.3	0.3	0.15	0.01				0.33	0.10			
252		11	0.2	0.2	0.10	0.00				0.33	0.07			
253		12	0.4	0.4	0.20	0.03				0.33	0.13			
254		13	0.2	0.2	0.10	0.00				0.33	0.07			
255		14	0.3	0.3	0.15	0.01				0.33	0.10			
256		15	0.2	0.2	0.10	0.00				0.33	0.07			
257		16	0.1	0.1	0.05	0.00				0.33	0.03			
258		17	0.5	0.5	0.25	0.07				0.33	0.17			
259		18	4.0	2.3	1.13	3.74				0.33	0.74			
260		19	0.9	0.9	0.45	0.38				0.33	0.30			
261		20	0.9	0.9	0.45	0.38				0.33	0.30			
262		21	0.7	0.7	0.35	0.18				0.33	0.23			
263		22	0.2	0.2	0.10	0.00				0.33	0.07			
264		23	0.1	0.1	0.05	0.00				0.33	0.03			
265		24	0.2	0.2	0.10	0.00				0.33	0.07			
266		25	0.4	0.4	0.20	0.03				0.33	0.13			
267		26	0.9	0.9	0.45	0.38				0.33	0.30			
268		27	0.3	0.3	0.15	0.01				0.33	0.10			
269		28	0.2	0.2	0.10	0.00				0.33	0.07			
270		29	0.4	0.4	0.20	0.03				0.33	0.13			
271		30	0.2	0.2	0.10	0.00				0.33	0.07			
272		31	0.3	0.3	0.15	0.01				0.33	0.10			
273		32	0.2	0.2	0.10	0.00				0.33	0.07			
274		33	0.1	0.1	0.05	0.00				0.33	0.03			
275		34	0.5	0.5	0.25	0.07				0.33	0.17			
276														
277		1	2.3	1.7	0.86	2.04	8.17			0.33	0.56	0.175	0.12	0.71
278		2	0.9	0.9	0.45	0.38				0.33	0.30			
279		3	0.9	0.9	0.45	0.38				0.33	0.30			
280		4	0.2	0.2	0.10	0.00				0.33	0.07			
281		5	0.6	0.6	0.30	0.11				0.33	0.20			
282		6	0.3	0.3	0.15	0.01				0.33	0.10			
283		7	0.2	0.2	0.10	0.00				0.33	0.07			
284		8	0.5	0.5	0.25	0.07				0.33	0.17			
285		9	0.2	0.2	0.10	0.00				0.33	0.07			
286		10	0.4	0.4	0.20	0.03				0.33	0.13			
287		11	0.6	0.6	0.30	0.11				0.33	0.20			
288		12	0.7	0.7	0.35	0.18				0.33	0.23			
289		13	0.9	0.9	0.45	0.38				0.33	0.30			
290		14	0.6	0.6	0.30	0.11				0.33	0.20			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
291		15	0.5	0.5	0.25	0.07				0.33	0.17			
292		16	0.2	0.2	0.10	0.00				0.33	0.07			
293		17	0.2	0.2	0.10	0.00				0.33	0.07			
294		18	0.1	0.1	0.05	0.00				0.33	0.03			
295		19	0.2	0.2	0.10	0.00				0.33	0.07			
296		20	0.7	0.7	0.35	0.18				0.33	0.23			
297		21	2.3	1.7	0.86	2.04				0.33	0.56			
298		22	0.9	0.9	0.45	0.38				0.33	0.30			
299		23	0.9	0.9	0.45	0.38				0.33	0.30			
300		24	0.2	0.2	0.10	0.00				0.33	0.07			
301		25	0.6	0.6	0.30	0.11				0.33	0.20			
302		26	0.3	0.3	0.15	0.01				0.33	0.10			
303		27	0.2	0.2	0.10	0.00				0.33	0.07			
304		28	0.5	0.5	0.25	0.07				0.33	0.17			
305		29	0.2	0.2	0.10	0.00				0.33	0.07			
306		30	0.4	0.4	0.20	0.03				0.33	0.13			
307		31	0.6	0.6	0.30	0.11				0.33	0.20			
308		32	0.7	0.7	0.35	0.18				0.33	0.23			
309		33	0.9	0.9	0.45	0.38				0.33	0.30			
310		34	0.6	0.6	0.30	0.11				0.33	0.20			
311		35	0.5	0.5	0.25	0.07				0.33	0.17			
312		36	0.2	0.2	0.10	0.00				0.33	0.07			
313		37	0.2	0.2	0.10	0.00				0.33	0.07			
314		38	0.1	0.1	0.05	0.00				0.33	0.03			
315		39	0.2	0.2	0.10	0.00				0.33	0.07			
316		40	0.7	0.7	0.35	0.18				0.33	0.23			
317														
318	F55.2	1	6.0	2.8	1.38	5.74	10.53			0.25	0.69	0.202	0.15	0.76
319		2	0.2	0.2	0.10	0.00				0.25	0.05			
320		3	0.4	0.4	0.20	0.03				0.25	0.10			
321		4	1.5	1.4	0.69	1.24				0.25	0.35			
322		5	0.5	0.5	0.25	0.07				0.25	0.13			
323		6	0.9	0.9	0.45	0.38				0.25	0.23			
324		7	0.4	0.4	0.20	0.03				0.25	0.10			
325		8	0.6	0.6	0.30	0.11				0.25	0.15			
326		9	1.0	1.0	0.50	0.52				0.25	0.25			
327		10	0.6	0.6	0.30	0.11				0.25	0.15			
328		11	0.7	0.7	0.35	0.18				0.25	0.18			
329		12	1.2	1.2	0.60	0.87				0.25	0.30			
330		13	0.4	0.4	0.20	0.03				0.25	0.10			
331		14	0.8	0.8	0.40	0.27				0.25	0.20			
332		15	0.5	0.5	0.25	0.07				0.25	0.13			
333		16	1.2	1.2	0.60	0.87				0.25	0.30			
334		17	0.2	0.2	0.10	0.00				0.25	0.05			
335														
336	F67.1	1	0.4	0.4	0.20	0.03	0.10	1.70		0.12	0.05	0.044	0.02	0.42
337		2	0.2	0.2	0.10	0.00				0.12	0.02			
338		3	0.5	0.5	0.25	0.07				0.12	0.06			
339														
340		1	3.3	2.1	1.03	3.04	3.30			0.12	0.25	0.076	0.08	1.00
341		2	0.3	0.3	0.15	0.01				0.12	0.04			
342		3	0.4	0.4	0.20	0.03				0.12	0.05			
343		4	0.6	0.6	0.30	0.11				0.12	0.07			
344		5	0.5	0.5	0.25	0.07				0.12	0.06			
345		6	0.2	0.2	0.10	0.00				0.12	0.02			
346		7	0.4	0.4	0.20	0.03				0.12	0.05			
347														
348	F67.2	1	0.3	0.3	0.15	0.01	0.20	1.34		0.12	0.04	0.048	0.03	0.66

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
349		2	0.7	0.7	0.35	0.18				0.12	0.08			
350		3	0.2	0.2	0.10	0.00				0.12	0.02			
351														
352		1	0.5	0.5	0.25	0.07	2.47			0.12	0.06	0.098	0.06	0.60
353		2	0.4	0.4	0.20	0.03				0.12	0.05			
354		3	1.0	1.0	0.50	0.52				0.12	0.12			
355		4	0.6	0.6	0.30	0.11				0.12	0.07			
356		5	2.0	1.6	0.80	1.74				0.12	0.19			
357														
358	F67.4	1	0.2	0.2	0.10	0.00	0.30	0.32		0.12	0.02	0.060	0.03	0.53
359		2	0.7	0.7	0.35	0.18				0.12	0.08			
360		3	0.6	0.6	0.30	0.11				0.12	0.07			
361														
362		1	0.8	0.8	0.40	0.27	0.33			0.12	0.10	0.056	0.04	0.75
363		2	0.1	0.1	0.05	0.00				0.12	0.01			
364		3	0.5	0.5	0.25	0.07				0.12	0.06			
365														
366	F70.1	1	1.0	1.0	0.50	0.52	5.73	3.19		0.33	0.33	0.193	0.14	0.75
367		2	3.0	2.0	0.98	2.74				0.33	0.65			
368		3	1.2	1.2	0.60	0.87				0.33	0.40			
369		4	0.1	0.1	0.05	0.00				0.33	0.03			
370		5	0.1	0.1	0.05	0.00				0.33	0.03			
371		6	0.2	0.2	0.10	0.00				0.33	0.07			
372		7	0.8	0.8	0.40	0.27				0.33	0.26			
373		8	0.2	0.2	0.10	0.00				0.33	0.07			
374		9	0.6	0.6	0.30	0.11				0.33	0.20			
375		10	0.5	0.5	0.25	0.07				0.33	0.17			
376		11	0.6	0.6	0.30	0.11				0.33	0.20			
377		12	0.8	0.8	0.40	0.27				0.33	0.26			
378		13	0.4	0.4	0.20	0.03				0.33	0.13			
379		14	0.8	0.8	0.40	0.27				0.33	0.26			
380		15	0.5	0.5	0.25	0.07				0.33	0.17			
381		16	0.2	0.2	0.10	0.00				0.33	0.07			
382		17	0.1	0.1	0.05	0.00				0.33	0.03			
383		18	0.7	0.7	0.35	0.18				0.33	0.23			
384		19	0.4	0.4	0.20	0.03				0.33	0.13			
385		20	0.6	0.6	0.30	0.11				0.33	0.20			
386		21	0.5	0.5	0.25	0.07				0.33	0.17			
387														
388		1	0.6	0.6	0.30	0.11	0.66			0.33	0.20	0.165	0.07	0.43
389		2	0.8	0.8	0.40	0.27				0.33	0.26			
390		3	0.5	0.5	0.25	0.07				0.33	0.17			
391		4	0.1	0.1	0.05	0.00				0.33	0.03			
392		5	0.6	0.6	0.30	0.11				0.33	0.20			
393		6	0.5	0.5	0.25	0.07				0.33	0.17			
394		7	0.4	0.4	0.20	0.03				0.33	0.13			
395														
396	F70.3	1	14.1	4.2	2.12	• • •	14.40	9.97		0.12	0.51	0.190	0.21	1.12
397		2	0.8	0.8	0.40	0.27				0.12	0.10			
398		3	0.7	0.7	0.35	0.18				0.12	0.08			
399		4	0.6	0.6	0.30	0.11				0.12	0.07			
400														
401		1	5.7	2.7	1.35	5.44	5.55			0.12	0.32	0.117	0.14	1.18
402		2	0.4	0.4	0.20	0.03				0.12	0.05			
403		3	0.5	0.5	0.25	0.07				0.12	0.06			
404		4	0.3	0.3	0.15	0.01				0.12	0.04			
405														
406	F70.4	1	3.0	2.0	0.98	2.74	3.56	4.90		0.12	0.23	0.125	0.08	0.64

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
407		2	0.8	0.8	0.40	0.27				0.12	0.10			
408		3	0.4	0.4	0.20	0.03				0.12	0.05			
409		4	1.0	1.0	0.50	0.52				0.12	0.12			
410														
411		1	6.0	2.8	1.38	5.74	6.24			0.12	0.33	0.095	0.11	1.12
412		2	0.8	0.8	0.40	0.27				0.12	0.10			
413		3	0.4	0.4	0.20	0.03				0.12	0.05			
414		4	0.6	0.6	0.30	0.11				0.12	0.07			
415		5	0.5	0.5	0.25	0.07				0.12	0.06			
416		6	0.2	0.2	0.10	0.00				0.12	0.02			
417		7	0.3	0.3	0.15	0.01				0.12	0.04			
418														
419	F72.8	1	0.1	0.1	0.05	0.00	0.00	0.01		0.12	0.01	0.018	0.01	0.47
420		2	0.2	0.2	0.10	0.00				0.12	0.02			
421														
422		1	0.2	0.2	0.10	0.00	0.02			0.12	0.02	0.030	0.11	0.28
423		2	0.3	0.3	0.15	0.01				0.12	0.04			
424														
425	F75.9	1	1.0	1.0	0.50	0.52	2.53	2.14		0.19	0.19	0.215	0.08	0.37
426		2	0.8	0.8	0.40	0.27				0.19	0.15			
427		3	2.0	1.6	0.80	1.74				0.19	0.30			
428														
429		1	2.0	1.6	0.80	1.74	1.74			0.19	0.30	0.171	0.19	1.10
430		2	0.2	0.2	0.10	0.00				0.19	0.04			
431														
432	F76.0	1	1.2	1.2	0.60	0.87	1.08			0.19	0.23	0.092	0.08	0.84
433		2	0.1	0.1	0.05	0.00				0.19	0.02			
434		3	0.6	0.6	0.30	0.11				0.19	0.11			
435		4	0.1	0.1	0.05	0.00				0.19	0.02			
436		5	0.5	0.5	0.25	0.07				0.19	0.10			
437		6	0.4	0.4	0.20	0.03				0.19	0.08			
438														
439	F76.2	1	12.0	3.9	1.95	***	12.81	11.81		0.12	0.47	0.216	0.23	1.06
440		2	0.2	0.2	0.10	0.00				0.12	0.02			
441		3	1.3	1.3	0.65	1.06				0.12	0.16			
442														
443		1	11.0	3.7	1.87	***	10.80			0.12	0.45	0.174	0.24	1.38
444		2	0.5	0.5	0.25	0.07				0.12	0.06			
445		3	0.1	0.1	0.05	0.00				0.12	0.01			
446														
447	F84.9	1	1.0	1.0	0.50	0.52	3.09			0.21	0.21	0.127	0.09	0.70
448		2	0.2	0.2	0.10	0.00				0.21	0.04			
449		3	0.4	0.4	0.20	0.03				0.21	0.08			
450		4	0.4	0.4	0.20	0.03				0.21	0.08			
451		5	0.6	0.6	0.30	0.11				0.21	0.13			
452		6	0.6	0.6	0.30	0.11				0.21	0.13			
453		7	0.8	0.8	0.40	0.27				0.21	0.17			
454		8	2.2	1.7	0.84	1.94				0.21	0.35			
455		9	0.3	0.3	0.15	0.01				0.21	0.06			
456		10	0.3	0.3	0.15	0.01				0.21	0.06			
457		11	0.4	0.4	0.20	0.03				0.21	0.08			
458														
459	F85.0	1	0.3	0.3	0.15	0.01	0.28			0.12	0.04	0.048	0.04	0.90
460		2	0.1	0.1	0.05	0.00				0.12	0.01			
461		3	0.8	0.8	0.40	0.27				0.12	0.10			
462														
463	F93.7	1	8.3	3.3	1.63	8.04	8.30	5.98		0.12	0.39	0.116	0.16	1.33
464		2	0.1	0.1	0.05	0.00				0.12	0.01			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
465		3	0.5	0.5	0.25	0.07				0.12	0.06			
466		4	0.3	0.3	0.15	0.01				0.12	0.04			
467		5	0.7	0.7	0.35	0.18				0.12	0.08			
468														
469		1	3.5	2.1	1.06	3.24	3.65			0.12	0.25	0.136	0.11	0.77
470		2	0.4	0.4	0.20	0.03				0.12	0.05			
471		3	0.9	0.9	0.45	0.38				0.12	0.11			
472														
473	F100.1	1	0.1	0.1	0.05	0.00	0.00	0.09		0.12	0.01	0.012		
474														
475		1	0.7	0.7	0.35	0.18	0.18			0.12	0.08	0.040	0.04	0.96
476		2	0.2	0.2	0.10	0.00				0.12	0.02			
477		3	0.1	0.1	0.05	0.00				0.12	0.01			
478														
479	F100.3	1	0.3	0.3	0.15	0.01	0.01	1.85		0.12	0.04	0.036		
480														
481		1	2.7	1.9	0.93	2.44	3.68			0.12	0.22	0.003	0.11	***
482		2	1.5	1.4	0.69	1.24				0.12	0.17			
483		3	0.1	0.1	0.05	0.00				0.12	0.01			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Appendix 1e: Volumetric pellet data for TACTS borehole G													
2														
3														
4	Sample #	Grain no.	MGU	D	R	V	TV	AVV		MF	TGD	M TGD	STDEV	CV
5														
6	G5.8	1	1.0	1.0	0.50	0.52	0.67			0.49	0.49	0.40	0.12	0.30
7		2	0.7	0.7	0.33	0.14				0.49	0.32			
8														
9	G7.6	1	1.0	1.0	0.50	0.52	0.70	0.81		0.30	0.30	0.26	0.06	0.25
10		2	0.7	0.7	0.35	0.18				0.30	0.21			
11														
12		1	1.0	1.0	0.50	0.52	0.92			0.30	0.30	0.22	0.11	0.52
13		2	0.9	0.9	0.45	0.38				0.30	0.27			
14		3	0.3	0.3	0.15	0.01				0.30	0.09			
15														
16	G8.5	1	2.0	1.6	0.80	1.74	1.85	1.69		0.33	0.53	0.36	0.23	0.64
17		2	0.6	0.6	0.30	0.11				0.33	0.20			
18														
19		3	1.5	1.4	0.69	1.24	1.52			0.33	0.46	0.21	0.19	0.89
20		4	0.1	0.1	0.05	0.00				0.33	0.03			
21		5	0.8	0.8	0.40	0.27				0.33	0.26			
22		6	0.3	0.3	0.15	0.01				0.33	0.10			
23														
24	G9.3	1	0.9	0.9	0.45	0.38	0.39	0.94		0.49	0.44	0.20	0.21	1.09
25		2	0.1	0.1	0.05	0.00				0.49	0.05			
26		3	0.2	0.2	0.10	0.00				0.49	0.10			
27														
28		1	1.8	1.5	0.75	1.49	1.49			0.49	0.73	0.28	0.39	1.43
29		2	0.1	0.1	0.05	0.00				0.49	0.05			
30		3	0.1	0.1	0.05	0.00				0.49	0.05			
31														
32	G10.7	1	1.0	1.0	0.50	0.52	1.83	1.91		0.12	0.12	0.07	0.03	0.43
33		2	0.9	0.9	0.45	0.38				0.12	0.11			
34		3	0.5	0.5	0.25	0.07				0.12	0.06			
35		4	0.6	0.6	0.30	0.11				0.12	0.07			
36		5	0.7	0.7	0.35	0.18				0.12	0.08			
37		6	0.2	0.2	0.10	0.00				0.12	0.02			
38		7	0.2	0.2	0.10	0.00				0.12	0.02			
39		8	0.7	0.7	0.35	0.18				0.12	0.08			
40		9	0.8	0.8	0.40	0.27				0.12	0.10			
41		10	0.6	0.6	0.30	0.11				0.12	0.07			
42														
43		1	0.6	0.6	0.30	0.11	1.98			0.12	0.07	0.07	0.02	0.22
44		2	0.6	0.6	0.30	0.11				0.12	0.07			
45		3	0.6	0.6	0.30	0.11				0.12	0.07			
46		4	0.6	0.6	0.30	0.11				0.12	0.07			
47		5	0.6	0.6	0.30	0.11				0.12	0.07			
48		6	0.6	0.6	0.30	0.11				0.12	0.07			
49		7	0.6	0.6	0.30	0.11				0.12	0.07			
50		8	0.7	0.7	0.35	0.18				0.12	0.08			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
51		9	0.7	0.7	0.35	0.18				0.12	0.08			
52		10	0.8	0.8	0.40	0.27				0.12	0.10			
53		11	0.7	0.7	0.35	0.18				0.12	0.09			
54		12	0.8	0.8	0.40	0.27				0.12	0.10			
55		13	0.3	0.3	0.15	0.01				0.12	0.04			
56		14	0.4	0.4	0.20	0.03				0.12	0.05			
57		15	0.5	0.5	0.25	0.07				0.12	0.06			
58														
59	G11.3	1	1.0	1.0	0.50	0.52	0.80	1.60		0.12	0.12	0.06	0.04	0.62
60		2	0.1	0.1	0.05	0.00				0.12	0.01			
61		3	0.6	0.6	0.30	0.11				0.12	0.07			
62		4	0.6	0.6	0.30	0.11				0.12	0.07			
63		5	0.3	0.3	0.15	0.01				0.12	0.04			
64		6	0.4	0.4	0.20	0.03				0.12	0.05			
65														
66		1	0.3	0.3	0.15	0.01	2.40			0.12	0.04	0.09	0.04	0.48
67		2	0.9	0.9	0.45	0.38				0.12	0.11			
68		3	1.0	1.0	0.50	0.52				0.12	0.12			
69		4	0.2	0.2	0.10	0.00				0.12	0.02			
70		5	0.8	0.8	0.40	0.27				0.12	0.10			
71		6	1.1	1.1	0.55	0.69				0.12	0.13			
72		7	1.0	1.0	0.50	0.52				0.12	0.12			
73														
74	G14.0	1	1.0	1.0	0.50	0.52	1.45	1.83		0.13	0.13	0.07	0.04	0.59
75		2	0.5	0.5	0.25	0.07				0.13	0.07			
76		3	0.9	0.9	0.45	0.38				0.13	0.12			
77		4	0.4	0.4	0.20	0.03				0.13	0.05			
78		5	0.6	0.6	0.30	0.11				0.13	0.08			
79		6	0.8	0.8	0.40	0.27				0.13	0.10			
80		7	0.5	0.5	0.25	0.07				0.13	0.07			
81		8	0.1	0.1	0.05	0.00				0.13	0.01			
82		9	0.1	0.1	0.05	0.00				0.13	0.01			
83														
84		1	1.0	1.0	0.50	0.52	2.20			0.13	0.13	0.08	0.04	0.58
85		2	0.3	0.3	0.15	0.01				0.13	0.04			
86		3	0.1	0.1	0.05	0.00				0.13	0.01			
87		4	0.2	0.2	0.10	0.00				0.13	0.03			
88		5	1.0	1.0	0.50	0.52				0.13	0.13			
89		6	0.4	0.4	0.20	0.03				0.13	0.05			
90		7	0.7	0.7	0.35	0.18				0.13	0.09			
91		8	0.8	0.8	0.40	0.27				0.13	0.10			
92		9	0.6	0.6	0.30	0.11				0.13	0.08			
93		10	1.0	1.0	0.50	0.52				0.13	0.13			
94		11	0.3	0.3	0.15	0.01				0.13	0.04			
95														
96	G17.1	1	1.0	1.0	0.50	0.52	4.38	3.75		0.15	0.15	0.11	0.06	0.59
97		2	0.5	0.5	0.25	0.07				0.15	0.08			
98		3	1.0	1.0	0.50	0.52				0.15	0.15			
99		4	0.3	0.3	0.15	0.01				0.15	0.05			
100		5	1.0	1.0	0.50	0.52				0.15	0.15			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
101		6	0.4	0.4	0.20	0.03				0.15	0.06			
102		7	0.3	0.3	0.15	0.01				0.15	0.05			
103		8	2.0	1.6	0.80	1.74				0.15	0.24			
104		9	0.4	0.4	0.20	0.03				0.15	0.06			
105		10	1.0	1.0	0.50	0.52				0.15	0.15			
106		11	0.9	0.9	0.45	0.38				0.15	0.14			
107		12	0.2	0.2	0.10	0.00				0.15	0.03			
108														
109		1	0.8	0.8	0.40	0.27	3.12			0.12	0.10	0.10	0.04	0.45
110		2	1.0	1.0	0.50	0.52				0.12	0.12			
111		3	1.0	1.0	0.50	0.52				0.12	0.12			
112		4	1.3	1.3	0.65	1.06				0.12	0.16			
113		5	0.4	0.4	0.20	0.03				0.12	0.05			
114		6	0.7	0.7	0.35	0.18				0.12	0.08			
115		7	0.2	0.2	0.10	0.00				0.12	0.02			
116		8	1.0	1.0	0.50	0.52				0.12	0.12			
117														
118	G22.9	1	0.9	0.9	0.45	0.38	3.66			0.12	0.11	0.08	0.03	0.30
119		2	0.9	0.9	0.45	0.38				0.12	0.11			
120		3	0.9	0.9	0.45	0.38				0.12	0.11			
121		4	0.9	0.9	0.45	0.38				0.12	0.11			
122		5	0.9	0.9	0.45	0.38				0.12	0.11			
123		6	0.9	0.9	0.45	0.38				0.12	0.11			
124		7	0.3	0.3	0.15	0.01				0.12	0.04			
125		8	0.3	0.3	0.15	0.01				0.12	0.04			
126		9	0.8	0.8	0.40	0.27				0.12	0.10			
127		10	0.8	0.8	0.40	0.27				0.12	0.10			
128		11	0.8	0.8	0.40	0.27				0.12	0.10			
129		12	0.7	0.7	0.35	0.18				0.12	0.09			
130		13	0.6	0.6	0.30	0.11				0.12	0.07			
131		14	0.6	0.6	0.30	0.11				0.12	0.07			
132		15	0.5	0.5	0.25	0.07				0.12	0.06			
133		16	0.5	0.5	0.25	0.07				0.12	0.06			
134														
135	G25.9	1	0.6	0.6	0.30	0.11	3.00	1.94		0.12	0.07	0.00	0.03	58.16
136		2	0.6	0.6	0.30	0.11				0.12	0.07			
137		3	0.6	0.6	0.30	0.11				0.12	0.07			
138		4	0.7	0.7	0.35	0.18				0.12	0.08			
139		5	0.9	0.9	0.45	0.38				0.12	0.11			
140		6	0.3	0.3	0.15	0.01				0.12	0.04			
141		7	0.9	0.9	0.45	0.38				0.12	0.11			
142		8	0.9	0.9	0.45	0.38				0.12	0.11			
143		9	0.7	0.7	0.35	0.18				0.12	0.08			
144		10	1.4	1.3	0.67	1.14				0.12	0.16			
145														
146		1	0.9	0.9	0.45	0.38	0.88			0.12	0.11	0.08	0.04	0.51
147		2	0.9	0.9	0.45	0.38				0.12	0.11			
148		3	0.2	0.2	0.10	0.00				0.12	0.02			
149		4	0.6	0.6	0.30	0.11				0.12	0.07			
150														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
151	G29.0	1	1.0	1.0	0.50	0.52	2.08	2.33		0.12	0.12	0.10	0.06	0.25
152		2	1.0	1.0	0.50	0.52				0.12	0.12			
153		3	0.8	0.8	0.40	0.27				0.12	0.10			
154		4	0.5	0.5	0.25	0.07				0.12	0.06			
155		5	0.7	0.7	0.35	0.18				0.12	0.08			
156		6	1.0	1.0	0.50	0.52				0.12	0.12			
157														
158		1	1.0	1.0	0.50	0.52	2.57			0.12	0.12	0.09	0.04	0.39
159		2	0.5	0.5	0.25	0.07				0.12	0.06			
160		3	0.6	0.6	0.30	0.11				0.12	0.07			
161		4	0.4	0.4	0.20	0.03				0.12	0.05			
162		5	0.5	0.5	0.25	0.07				0.12	0.06			
163		6	1.0	1.0	0.50	0.52				0.12	0.12			
164		7	1.2	1.2	0.60	0.87				0.12	0.14			
165		8	0.9	0.9	0.45	0.38				0.12	0.11			
166														
167	G32.0	1	0.4	0.4	0.20	0.03	0.34	0.63		0.12	0.05	0.06	0.02	0.27
168		2	0.5	0.5	0.25	0.07				0.12	0.06			
169		3	0.6	0.6	0.30	0.11				0.12	0.07			
170		4	0.3	0.3	0.15	0.01				0.12	0.04			
171		5	0.6	0.6	0.30	0.11				0.12	0.07			
172														
173		1	0.8	0.8	0.40	0.27	0.91			0.12	0.10	0.07	0.03	0.45
174		2	0.7	0.7	0.35	0.18				0.12	0.08			
175		3	0.2	0.2	0.10	0.00				0.12	0.02			
176		4	0.3	0.3	0.15	0.01				0.12	0.04			
177		5	0.7	0.7	0.35	0.18				0.12	0.08			
178		6	0.8	0.8	0.40	0.27				0.12	0.10			
179														
180	G35.2	1	0.8	0.8	0.40	0.27	2.74	1.91		0.12	0.10	0.10	0.05	0.48
181		2	0.2	0.2	0.10	0.00				0.12	0.02			
182		3	0.5	0.5	0.25	0.07				0.12	0.06			
183		4	0.9	0.9	0.45	0.38				0.12	0.11			
184		5	1.1	1.1	0.55	0.69				0.12	0.13			
185		6	1.3	1.3	0.65	1.06				0.12	0.16			
186		7	0.8	0.8	0.40	0.27				0.12	0.10			
187														
188		1	0.8	0.8	0.40	0.27	1.08			0.12	0.10	0.06	0.05	0.74
189		2	0.2	0.2	0.10	0.00				0.12	0.02			
190		3	0.2	0.2	0.10	0.00				0.12	0.02			
191		4	1.1	1.1	0.55	0.69				0.12	0.13			
192		5	0.6	0.6	0.30	0.11				0.12	0.07			
193		6	0.2	0.2	0.10	0.00				0.12	0.02			
194														
195	G38.1	1	1.1	1.1	0.55	0.69	2.09	1.33		0.12	0.13	0.00	0.02	31.71
196		2	0.5	0.5	0.25	0.07				0.12	0.06			
197		3	0.5	0.5	0.25	0.07				0.12	0.06			
198		4	0.7	0.7	0.35	0.18				0.12	0.08			
199		5	0.8	0.8	0.40	0.27				0.12	0.10			
200		6	0.7	0.7	0.35	0.18				0.12	0.08			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
201		7	0.5	0.5	0.25	0.07				0.12	0.06			
202		8	0.4	0.4	0.20	0.03				0.12	0.05			
203		9	0.8	0.8	0.40	0.27				0.12	0.10			
204		10	0.4	0.4	0.20	0.03				0.12	0.05			
205		11	0.5	0.5	0.25	0.07				0.12	0.06			
206		12	0.7	0.7	0.35	0.18				0.12	0.08			
207														
208		1	0.5	0.5	0.25	0.07	0.57			0.12	0.06	0.00	0.03	••••
209		2	0.4	0.4	0.20	0.03				0.12	0.05			
210		3	0.9	0.9	0.45	0.38				0.12	0.11			
211		4	0.2	0.2	0.10	0.00				0.12	0.02			
212		5	0.3	0.3	0.15	0.01				0.12	0.04			
213		6	0.2	0.2	0.10	0.00				0.12	0.02			
214		7	0.2	0.2	0.10	0.00				0.12	0.02			
215		8	0.5	0.5	0.25	0.07				0.12	0.06			
216														
217	G41.0	1	0.1	0.1	0.05	0.00	2.19	2.10		0.12	0.01	0.08	0.03	0.42
218		2	0.6	0.6	0.30	0.11				0.12	0.07			
219		3	0.6	0.6	0.30	0.11				0.12	0.07			
220		4	0.9	0.9	0.45	0.38				0.12	0.11			
221		5	0.5	0.5	0.25	0.07				0.12	0.06			
222		6	0.8	0.8	0.40	0.27				0.12	0.10			
223		7	1.1	1.1	0.55	0.69				0.12	0.13			
224		8	0.9	0.9	0.45	0.38				0.12	0.11			
225		9	0.7	0.7	0.35	0.18				0.12	0.08			
226														
227		1	0.6	0.6	0.30	0.11	2.01			0.12	0.07	0.07	0.04	0.57
228		2	1.2	1.2	0.60	0.87				0.12	0.14			
229		3	0.5	0.5	0.25	0.07				0.12	0.06			
230		4	0.2	0.2	0.10	0.00				0.12	0.02			
231		5	0.1	0.1	0.05	0.00				0.12	0.01			
232		6	0.3	0.3	0.15	0.01				0.12	0.04			
233		7	0.8	0.8	0.40	0.27				0.12	0.10			
234		8	0.9	0.9	0.45	0.38				0.12	0.11			
235		9	0.7	0.7	0.35	0.18				0.12	0.08			
236		10	0.6	0.6	0.30	0.11				0.12	0.07			
237														
238	G41.1	1	0.9	0.9	0.45	0.38	1.38	0.74		0.12	0.11	0.07	0.03	0.41
239		2	0.6	0.6	0.30	0.11				0.12	0.07			
240		3	0.8	0.8	0.40	0.27				0.12	0.10			
241		4	0.4	0.4	0.20	0.03				0.12	0.05			
242		5	0.3	0.3	0.15	0.01				0.12	0.04			
243		6	0.6	0.6	0.30	0.11				0.12	0.07			
244		7	0.8	0.8	0.40	0.27				0.12	0.10			
245		8	0.7	0.7	0.35	0.18				0.12	0.08			
246		9	0.2	0.2	0.10	0.00				0.12	0.02			
247														
248		1	0.5	0.5	0.25	0.07	0.11			0.12	0.06	0.04	0.02	0.53
249		2	0.1	0.1	0.05	0.00				0.12	0.01			
250		3	0.4	0.4	0.20	0.03				0.12	0.05			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
251		4	0.3	0.3	0.15	0.01				0.12	0.04			
252														
253	G44.2	1	0.9	0.9	0.45	0.38	0.89	0.74		0.12	0.11	0.09	0.02	0.24
254		2	0.7	0.7	0.35	0.18				0.12	0.08			
255		3	0.8	0.8	0.40	0.27				0.12	0.10			
256		4	0.5	0.5	0.25	0.07				0.12	0.06			
257														
258		1	0.6	0.6	0.30	0.11	0.59			0.12	0.07	0.06	0.03	0.43
259		2	0.3	0.3	0.15	0.01				0.12	0.04			
260		3	0.8	0.8	0.40	0.27				0.12	0.10			
261		4	0.3	0.3	0.15	0.01				0.12	0.04			
262		5	0.7	0.7	0.35	0.18				0.12	0.08			
263														
264	G47.5	1	0.8	0.8	0.40	0.27	1.58	1.35		0.12	0.10	0.07	0.04	0.53
265		2	0.2	0.2	0.10	0.00				0.12	0.02			
266		3	0.7	0.7	0.35	0.18				0.12	0.08			
267		4	0.9	0.9	0.45	0.38				0.12	0.11			
268		5	0.6	0.6	0.30	0.11				0.12	0.07			
269		6	0.5	0.5	0.25	0.07				0.12	0.06			
270		7	0.9	0.9	0.45	0.38				0.12	0.11			
271		8	0.1	0.1	0.05	0.00				0.12	0.01			
272		9	0.2	0.2	0.10	0.00				0.12	0.02			
273		10	0.7	0.7	0.35	0.18				0.12	0.08			
274														
275		1	0.1	0.1	0.05	0.00	1.12			0.12	0.01	0.05	0.04	0.80
276		2	0.5	0.5	0.25	0.07				0.12	0.06			
277		3	0.1	0.1	0.05	0.00				0.12	0.01			
278		4	1.0	1.0	0.50	0.52				0.12	0.12			
279		5	0.9	0.9	0.45	0.38				0.12	0.11			
280		6	0.6	0.6	0.30	0.11				0.12	0.07			
281		7	0.1	0.1	0.05	0.00				0.12	0.01			
282		8	0.4	0.4	0.20	0.03				0.12	0.05			
283		9	0.2	0.2	0.10	0.00				0.12	0.02			
284														
285	G50.6	1	0.8	0.8	0.40	0.27	1.44	0.94		0.12	0.10	0.08	0.03	0.36
286		2	0.9	0.9	0.45	0.38				0.12	0.11			
287		3	0.6	0.6	0.30	0.11				0.12	0.07			
288		4	0.4	0.4	0.20	0.03				0.12	0.05			
289		5	0.9	0.9	0.45	0.38				0.12	0.11			
290		6	0.5	0.5	0.25	0.07				0.12	0.06			
291		7	0.7	0.7	0.35	0.18				0.12	0.08			
292		8	0.3	0.3	0.15	0.01				0.12	0.04			
293														
294		1	0.4	0.4	0.20	0.03	0.45			0.12	0.05	0.07	0.02	0.35
295		2	0.4	0.4	0.20	0.03				0.12	0.05			
296		3	0.8	0.8	0.40	0.27				0.12	0.10			
297		4	0.6	0.6	0.30	0.11				0.12	0.07			
298														
299	G53.6	1	0.7	0.7	0.35	0.18	0.39			0.12	0.08	0.06	0.03	0.50
300		2	0.5	0.5	0.25	0.07				0.12	0.06			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
301		3	0.1	0.1	0.05	0.00				0.12	0.01			
302		4	0.6	0.6	0.30	0.11				0.12	0.07			
303		5	0.4	0.4	0.20	0.03				0.12	0.05			
304														
305	G56.7	1	1.0	1.0	0.50	0.52	1.21	1.31		0.12	0.12	0.00	0.01	8.05
306		2	1.1	1.1	0.55	0.69				0.12	0.13			
307														
308		1	0.8	0.8	0.40	0.27	1.42			0.12	0.10	0.00	0.02	47.09
309		2	0.7	0.7	0.35	0.18				0.12	0.08			
310		3	1.0	1.0	0.50	0.52				0.12	0.12			
311		4	0.9	0.9	0.45	0.38				0.12	0.11			
312		5	0.5	0.5	0.25	0.07				0.12	0.06			
313														
314	G60.0	1	0.80	0.80	0.40	0.27	11.79			0.33	0.26	0.09	0.13	1.48
315		2	2.50	1.8	0.89	2.24				0.33	0.59			
316		3	0.10	0.10	0.05	0.00				0.33	0.03			
317		4	0.10	0.10	0.05	0.00				0.33	0.03			
318		5	0.10	0.10	0.05	0.00				0.33	0.03			
319		6	0.10	0.10	0.05	0.00				0.33	0.03			
320		7	0.10	0.10	0.05	0.00				0.33	0.03			
321		8	0.10	0.10	0.05	0.00				0.33	0.03			
322		9	0.10	0.10	0.05	0.00				0.33	0.03			
323		10	0.10	0.10	0.05	0.00				0.33	0.03			
324		11	0.10	0.10	0.05	0.00				0.33	0.03			
325		12	0.10	0.10	0.05	0.00				0.33	0.03			
326		13	0.10	0.10	0.05	0.00				0.33	0.03			
327		14	0.10	0.10	0.05	0.00				0.33	0.03			
328		15	0.10	0.10	0.05	0.00				0.33	0.03			
329		16	0.10	0.10	0.05	0.00				0.33	0.03			
330		17	0.10	0.10	0.05	0.00				0.33	0.03			
331		18	0.20	0.20	0.10	0.00				0.33	0.07			
332		19	0.50	0.50	0.25	0.07				0.33	0.17			
333		20	0.70	0.70	0.35	0.18				0.33	0.23			
334		21	0.80	0.80	0.40	0.27				0.33	0.26			
335		22	2.50	1.8	0.89	2.98				0.33	0.59			
336		23	0.10	0.10	0.05	0.00				0.33	0.03			
337		24	0.10	0.10	0.05	0.00				0.33	0.03			
338		25	0.10	0.10	0.05	0.00				0.33	0.03			
339		26	0.10	0.10	0.05	0.00				0.33	0.03			
340		27	0.10	0.10	0.05	0.00				0.33	0.03			
341		28	0.10	0.10	0.05	0.00				0.33	0.03			
342		29	0.10	0.10	0.05	0.00				0.33	0.03			
343		30	0.10	0.10	0.05	0.00				0.33	0.03			
344		31	0.10	0.10	0.05	0.00				0.33	0.03			
345		32	0.10	0.10	0.05	0.00				0.33	0.03			
346		33	0.10	0.10	0.05	0.00				0.33	0.03			
347		34	0.10	0.10	0.05	0.00				0.33	0.03			
348		35	0.10	0.10	0.05	0.00				0.33	0.03			
349		36	0:10	0.10	0.05	0.00				0.33	0.03			
350		37	0.10	0.10	0.05	0.00				0.33	0.03			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
351		38	0.20	0.20	0.10	0.00				0.33	0.07			
352		39	0.50	0.50	0.25	0.07				0.33	0.17			
353		40	0.70	0.70	0.35	0.18				0.33	0.23			
354		41	0.80	0.80	0.40	0.27				0.33	0.26			
355		42	2.50	1.8	0.89	2.24				0.33	0.59			
356		43	0.10	0.10	0.05	0.00				0.33	0.03			
357		44	0.10	0.10	0.05	0.00				0.33	0.03			
358		45	0.10	0.10	0.05	0.00				0.33	0.03			
359		46	0.10	0.10	0.05	0.00				0.33	0.03			
360		47	0.10	0.10	0.05	0.00				0.33	0.03			
361		48	0.10	0.10	0.05	0.00				0.33	0.03			
362		49	0.10	0.10	0.05	0.00				0.33	0.03			
363		50	0.10	0.10	0.05	0.00				0.33	0.03			
364		51	0.10	0.10	0.05	0.00				0.33	0.03			
365		52	0.10	0.10	0.05	0.00				0.33	0.03			
366		53	0.10	0.10	0.05	0.00				0.33	0.03			
367		54	0.10	0.10	0.05	0.00				0.33	0.03			
368		55	0.10	0.10	0.05	0.00				0.33	0.03			
369		56	0.10	0.10	0.05	0.00				0.33	0.03			
370		57	0.10	0.10	0.05	0.00				0.33	0.03			
371		58	0.20	0.20	0.10	0.00				0.33	0.07			
372		59	0.50	0.50	0.25	0.07				0.33	0.17			
373		60	0.70	0.70	0.35	0.18				0.33	0.23			
374		61	0.80	0.80	0.40	0.27				0.33	0.26			
375		62	2.50	1.8	0.89	2.24				0.33	0.59			
376		63	0.10	0.10	0.05	0.00				0.33	0.03			
377		64	0.10	0.10	0.05	0.00				0.33	0.03			
378		65	0.10	0.10	0.05	0.00				0.33	0.03			
379		66	0.10	0.10	0.05	0.00				0.33	0.03			
380		67	0.10	0.10	0.05	0.00				0.33	0.03			
381		68	0.10	0.10	0.05	0.00				0.33	0.03			
382		69	0.10	0.10	0.05	0.00				0.33	0.03			
383		70	0.10	0.10	0.05	0.00				0.33	0.03			
384		71	0.10	0.10	0.05	0.00				0.33	0.03			
385		72	0.10	0.10	0.05	0.00				0.33	0.03			
386		73	0.10	0.10	0.05	0.00				0.33	0.03			
387		74	0.10	0.10	0.05	0.00				0.33	0.03			
388		75	0.10	0.10	0.05	0.00				0.33	0.03			
389		76	0.10	0.10	0.05	0.00				0.33	0.03			
390		77	0.10	0.10	0.05	0.00				0.33	0.03			
391		78	0.20	0.20	0.10	0.00				0.33	0.07			
392		79	0.50	0.50	0.25	0.07				0.33	0.17			
393		80	0.70	0.70	0.35	0.18				0.33	0.23			
394														
395	G63.4	1	1.0	1.0	0.50	0.52	2.91			0.21	0.21	0.14	0.11	0.77
396		2	0.5	0.5	0.25	0.07				0.21	0.11			
397		3	2.0	1.6	0.80	1.74				0.21	0.34			
398		4	1.0	1.0	0.50	0.52				0.21	0.21			
399		5	0.3	0.3	0.15	0.01				0.21	0.06			
400		6	0.2	0.2	0.10	0.00				0.21	0.04			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
401		7	0.4	0.4	0.20	0.03				0.21	0.08			
402		8	0.2	0.2	0.10	0.00				0.21	0.04			
403														
404	G63.6	1	0.6	0.6	0.30	0.11	1.97	2.71		0.19	0.11	0.12	0.06	0.46
405		2	0.6	0.6	0.30	0.11				0.19	0.11			
406		3	1.0	1.0	0.50	0.52				0.19	0.19			
407		4	1.1	1.1	0.55	0.69				0.19	0.21			
408		5	0.5	0.5	0.25	0.07				0.19	0.10			
409		6	0.2	0.2	0.10	0.00				0.19	0.04			
410		7	0.3	0.3	0.15	0.01				0.19	0.06			
411		8	0.7	0.7	0.35	0.18				0.19	0.13			
412		9	0.8	0.8	0.40	0.27				0.19	0.15			
413														
414		1	1.0	1.0	0.50	0.52	3.45			0.19	0.19	0.15	0.06	0.41
415		2	2.0	1.6	0.80	1.74				0.19	0.30			
416		3	0.7	0.7	0.35	0.18				0.19	0.13			
417		4	0.8	0.8	0.40	0.27				0.19	0.15			
418		5	0.6	0.6	0.30	0.11				0.19	0.11			
419		6	0.7	0.7	0.35	0.18				0.19	0.13			
420		7	0.5	0.5	0.25	0.07				0.19	0.10			
421		8	0.6	0.6	0.30	0.11				0.19	0.11			
422		9	0.8	0.8	0.40	0.27				0.19	0.15			
423														
424	G63.7	1	1.2	1.2	0.60	0.87	2.07	2.84		0.19	0.23	0.11	0.06	0.57
425		2	0.3	0.3	0.15	0.01				0.19	0.06			
426		3	0.1	0.1	0.05	0.00				0.19	0.02			
427		4	0.3	0.3	0.15	0.01				0.19	0.06			
428		5	0.9	0.9	0.45	0.38				0.19	0.17			
429		6	0.7	0.7	0.35	0.18				0.19	0.13			
430		7	0.6	0.6	0.30	0.11				0.19	0.11			
431		8	0.3	0.3	0.15	0.01				0.19	0.06			
432		9	0.4	0.4	0.20	0.03				0.19	0.08			
433		10	0.8	0.8	0.40	0.27				0.19	0.15			
434		11	0.7	0.7	0.35	0.18				0.19	0.13			
435														
436		1	0.8	0.8	0.40	0.27	3.61			0.19	0.15	0.15	0.04	0.25
437		2	0.7	0.7	0.35	0.18				0.19	0.13			
438		3	0.5	0.5	0.25	0.07				0.19	0.10			
439		4	0.6	0.6	0.30	0.11				0.19	0.11			
440		5	0.8	0.8	0.40	0.27				0.19	0.15			
441		6	1.0	1.0	0.50	0.52				0.19	0.19			
442		7	0.9	0.9	0.45	0.38				0.19	0.17			
443		8	1.1	1.1	0.55	0.69				0.19	0.21			
444		9	0.9	0.9	0.45	0.38				0.19	0.17			
445		10	0.9	0.9	0.45	0.38				0.19	0.17			
446		11	0.5	0.5	0.25	0.07				0.19	0.10			
447		12	0.6	0.6	0.30	0.11				0.19	0.11			
448		13	0.7	0.7	0.35	0.18				0.19	0.13			
449														
450	G66.0	1	0.9	0.9	0.45	0.38	7.07	8.55		0.19	0.17	0.17	0.07	0.43

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
451		2	1.0	1.0	0.50	0.52				0.19	0.19			
452		3	0.8	0.8	0.40	0.27				0.19	0.15			
453		4	0.3	0.3	0.15	0.01				0.19	0.06			
454		5	1.2	1.2	0.60	0.87				0.19	0.23			
455		6	0.9	0.9	0.45	0.38				0.19	0.17			
456		7	1.5	1.4	0.69	1.24				0.19	0.26			
457		8	0.9	0.9	0.45	0.38				0.19	0.17			
458		9	1.0	1.0	0.50	0.52				0.19	0.19			
459		10	0.5	0.5	0.25	0.07				0.19	0.10			
460		11	0.6	0.6	0.30	0.11				0.19	0.11			
461		12	1.5	1.4	0.69	1.24				0.19	0.26			
462		13	0.2	0.2	0.10	0.00				0.19	0.04			
463		14	1.3	1.3	0.65	1.06				0.19	0.25			
464														
465		1	1.3	1.3	0.65	1.06	10.03			0.19	0.25	0.19	0.08	0.43
466		2	0.9	0.9	0.45	0.38				0.19	0.17			
467		3	0.9	0.9	0.45	0.38				0.19	0.17			
468		4	1.3	1.3	0.65	1.06				0.19	0.25			
469		5	1.5	1.4	0.69	1.24				0.19	0.26			
470		6	0.8	0.8	0.40	0.27				0.19	0.15			
471		7	2.5	1.8	0.89	2.24				0.19	0.34			
472		8	1.0	1.0	0.50	0.52				0.19	0.19			
473		9	2.3	1.7	0.86	2.04				0.19	0.33			
474		10	0.5	0.5	0.25	0.07				0.19	0.10			
475		11	0.6	0.6	0.30	0.11				0.19	0.11			
476		12	1.0	1.0	0.50	0.52				0.19	0.19			
477		13	0.5	0.5	0.25	0.07				0.19	0.10			
478		14	0.5	0.5	0.25	0.07				0.19	0.10			
479														
480	G66.1	1	0.9	0.9	0.45	0.38	4.36			0.33	0.30	0.20	0.11	0.55
481		2	0.6	0.6	0.30	0.11				0.33	0.20			
482		3	0.4	0.4	0.20	0.03				0.33	0.13			
483		4	0.4	0.4	0.20	0.03				0.33	0.13			
484		5	0.5	0.5	0.25	0.07				0.33	0.17			
485		6	0.7	0.7	0.35	0.18				0.33	0.23			
486		7	0.8	0.8	0.40	0.27				0.33	0.26			
487		8	1.2	1.2	0.60	0.87				0.33	0.40			
488		9	0.3	0.3	0.15	0.01				0.33	0.10			
489		10	1.0	1.0	0.50	0.52				0.33	0.33			
490		11	0.5	0.5	0.25	0.07				0.33	0.17			
491		12	0.5	0.5	0.25	0.07				0.33	0.17			
492		13	1.5	1.4	0.69	1.24				0.33	0.46			
493		14	0.9	0.9	0.45	0.38				0.33	0.30			
494		15	0.3	0.3	0.15	0.01				0.33	0.10			
495		16	0.3	0.3	0.15	0.01				0.33	0.10			
496		17	0.3	0.3	0.15	0.01				0.33	0.10			
497		18	0.3	0.3	0.15	0.01				0.33	0.10			
498		19	0.2	0.2	0.10	0.00				0.33	0.07			
499		20	0.5	0.5	0.25	0.07				0.33	0.17			
500														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
501	G66.4	1	1.0	1.0	0.50	0.52	4.10			0.15	0.15	0.15	0.07	0.49
502		2	0.7	0.7	0.35	0.18				0.15	0.11			
503		3	2.8	1.9	0.94	2.54				0.15	0.28			
504		4	1.0	1.0	0.50	0.52				0.15	0.15			
505		5	0.8	0.8	0.40	0.27				0.15	0.12			
506		6	0.5	0.5	0.25	0.07				0.15	0.08			
507														
508	G66.8	1	0.7	0.7	0.35	0.18	2.95			0.25	0.18	0.19	0.07	0.39
509		2	1.2	1.2	0.60	0.87				0.25	0.30			
510		3	1.0	1.0	0.50	0.52				0.25	0.25			
511		4	0.9	0.9	0.45	0.38				0.25	0.23			
512		5	0.6	0.6	0.30	0.11				0.25	0.15			
513		6	0.2	0.2	0.10	0.00				0.25	0.05			
514		7	1.0	1.0	0.50	0.52				0.25	0.25			
515		8	0.6	0.6	0.30	0.11				0.25	0.15			
516		9	0.5	0.5	0.25	0.07				0.25	0.13			
517		10	0.7	0.7	0.35	0.18				0.25	0.18			
518														
519	G66.9	1	0.5	0.5	0.25	0.07	2.00			0.25	0.13	0.11	0.08	0.74
520		2	1.2	1.2	0.60	0.87				0.25	0.30			
521		3	0.1	0.1	0.05	0.00				0.25	0.03			
522		4	0.2	0.2	0.10	0.00				0.25	0.05			
523		5	1.0	1.0	0.50	0.52				0.25	0.25			
524		6	0.3	0.3	0.15	0.01				0.25	0.08			
525		7	0.3	0.3	0.15	0.01				0.25	0.08			
526		8	0.2	0.2	0.10	0.00				0.25	0.05			
527		9	0.8	0.8	0.40	0.27				0.25	0.20			
528		10	0.4	0.4	0.20	0.03				0.25	0.10			
529		11	0.3	0.3	0.15	0.01				0.25	0.08			
530		12	0.7	0.7	0.35	0.18				0.25	0.18			
531		13	0.2	0.2	0.10	0.00				0.25	0.05			
532		14	0.2	0.2	0.10	0.00				0.25	0.05			
533														
534	G69.5	1	0.5	0.5	0.25	0.07	27.19			0.21	0.11	0.15	0.10	0.65
535		2	0.5	0.5	0.25	0.07				0.21	0.11			
536		3	0.7	0.7	0.35	0.18				0.21	0.15			
537		4	1.2	1.2	0.60	0.87				0.21	0.25			
538		5	2.0	1.6	0.80	1.74				0.21	0.34			
539		6	0.9	0.9	0.45	0.38				0.21	0.19			
540		7	0.6	0.6	0.30	0.11				0.21	0.13			
541		8	0.8	0.8	0.40	0.27				0.21	0.17			
542		9	0.3	0.3	0.15	0.01				0.21	0.06			
543		10	0.5	0.5	0.25	0.07				0.21	0.11			
544		11	0.2	0.2	0.10	0.00				0.21	0.04			
545		12	0.1	0.1	0.05	0.00				0.21	0.02			
546		13	0.4	0.4	0.20	0.03				0.21	0.08			
547		14	0.5	0.5	0.25	0.07				0.21	0.11			
548		15	0.5	0.5	0.25	0.07				0.21	0.11			
549		16	0.7	0.7	0.35	0.18				0.21	0.15			
550		17	1.2	1.2	0.60	0.87				0.21	0.25			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
551		18	1.0	1.0	0.50	0.52				0.21	0.21			
552		19	0.2	0.2	0.10	0.00				0.21	0.04			
553		20	4.0	2.3	1.13	3.74				0.21	0.47			
554		21	0.9	0.9	0.45	0.38				0.21	0.19			
555		22	0.9	0.9	0.45	0.38				0.21	0.19			
556		23	0.5	0.5	0.25	0.07				0.21	0.11			
557		24	0.2	0.2	0.10	0.00				0.21	0.04			
558		25	0.1	0.1	0.05	0.00				0.21	0.02			
559		26	0.4	0.4	0.20	0.03				0.21	0.08			
560		27	0.5	0.5	0.25	0.07				0.21	0.11			
561		28	0.5	0.5	0.25	0.07				0.21	0.11			
562		29	0.7	0.7	0.35	0.18				0.21	0.15			
563		30	1.2	1.2	0.60	0.87				0.21	0.25			
564		31	2.0	1.6	0.80	1.74				0.21	0.34			
565		32	0.9	0.9	0.45	0.38				0.21	0.19			
566		33	0.6	0.6	0.30	0.11				0.21	0.13			
567		34	0.8	0.8	0.40	0.27				0.21	0.17			
568		35	0.3	0.3	0.15	0.01				0.21	0.06			
569		36	0.9	0.9	0.45	0.38				0.21	0.19			
570		37	1.0	1.0	0.50	0.52				0.21	0.21			
571		38	1.0	1.0	0.50	0.52				0.21	0.21			
572		39	0.2	0.2	0.10	0.00				0.21	0.04			
573		40	4.0	2.3	1.13	3.74				0.21	0.47			
574		41	0.9	0.9	0.45	0.38				0.21	0.19			
575		42	0.9	0.9	0.45	0.38				0.21	0.19			
576		43	0.5	0.5	0.25	0.07				0.21	0.11			
577		44	0.2	0.2	0.10	0.00				0.21	0.04			
578		45	0.1	0.1	0.05	0.00				0.21	0.02			
579		46	0.4	0.4	0.20	0.03				0.21	0.08			
580		47	0.5	0.5	0.25	0.07				0.21	0.11			
581		48	0.5	0.5	0.25	0.07				0.21	0.11			
582		49	0.7	0.7	0.35	0.18				0.21	0.15			
583		50	1.2	1.2	0.60	0.87				0.21	0.25			
584		51	2.0	1.6	0.80	1.74				0.21	0.34			
585		52	0.9	0.9	0.45	0.38				0.21	0.19			
586		53	0.6	0.6	0.30	0.11				0.21	0.13			
587		54	0.8	0.8	0.40	0.27				0.21	0.17			
588		55	0.3	0.3	0.15	0.01				0.21	0.06			
589														
590	G69.6	1	1.5	1.4	0.69	1.24	3.76	23.54		0.21	0.29	0.13	0.09	0.74
591		2	0.8	0.8	0.40	0.27				0.21	0.17			
592		3	0.3	0.3	0.15	0.01				0.21	0.06			
593		4	0.7	0.7	0.35	0.18				0.21	0.15			
594		5	2.0	1.6	0.80	1.74				0.21	0.34			
595		6	0.5	0.5	0.25	0.07				0.21	0.11			
596		7	0.2	0.2	0.10	0.00				0.21	0.04			
597		8	0.6	0.6	0.30	0.11				0.21	0.13			
598		9	0.4	0.4	0.20	0.03				0.21	0.08			
599		10	0.2	0.2	0.10	0.00				0.21	0.04			
600		11	0.2	0.2	0.10	0.00				0.21	0.04			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
601		12	0.4	0.4	0.20	0.03				0.21	0.08			
602		13	0.5	0.5	0.25	0.07				0.21	0.11			
603														
604		1	0.9	0.9	0.45	0.38	43.31			0.21	0.19	0.15	0.10	0.66
605		2	1.0	1.0	0.50	0.52				0.21	0.21			
606		3	1.0	1.0	0.50	0.52				0.21	0.21			
607		4	0.4	0.4	0.20	0.03				0.21	0.08			
608		5	0.2	0.2	0.10	0.00				0.21	0.04			
609		6	5.0	2.5	1.26	4.74				0.21	0.53			
610		7	0.6	0.6	0.30	0.11				0.21	0.13			
611		8	0.9	0.9	0.45	0.38				0.21	0.19			
612		9	0.5	0.5	0.25	0.07				0.21	0.11			
613		10	1.0	1.0	0.50	0.52				0.21	0.21			
614		11	0.2	0.2	0.10	0.00				0.21	0.04			
615		12	0.8	0.8	0.40	0.27				0.21	0.17			
616		13	0.2	0.2	0.10	0.00				0.21	0.04			
617		14	1.0	1.0	0.50	0.52				0.21	0.21			
618		15	0.2	0.2	0.10	0.00				0.21	0.04			
619		16	1.0	1.0	0.50	0.52				0.21	0.21			
620		17	0.3	0.3	0.15	0.01				0.21	0.06			
621		18	1.0	1.0	0.50	0.52				0.21	0.21			
622		19	1.0	1.0	0.50	0.52				0.21	0.21			
623		20	1.0	1.0	0.50	0.52				0.21	0.21			
624		21	0.1	0.1	0.05	0.00				0.21	0.02			
625		22	0.6	0.6	0.30	0.11				0.21	0.13			
626		23	0.5	0.5	0.25	0.07				0.21	0.11			
627		24	0.8	0.8	0.40	0.27				0.21	0.17			
628		25	0.7	0.7	0.35	0.18				0.21	0.15			
629		26	0.9	0.9	0.45	0.38				0.21	0.19			
630		27	1.0	1.0	0.50	0.52				0.21	0.21			
631		28	1.0	1.0	0.50	0.52				0.21	0.21			
632		29	0.4	0.4	0.20	0.03				0.21	0.08			
633		30	0.2	0.2	0.10	0.00				0.21	0.04			
634		31	5.0	2.5	1.26	4.74				0.21	0.53			
635		32	0.6	0.6	0.30	0.11				0.21	0.13			
636		33	0.9	0.9	0.45	0.38				0.21	0.19			
637		34	0.5	0.5	0.25	0.07				0.21	0.11			
638		35	1.0	1.0	0.50	0.52				0.21	0.21			
639		36	0.2	0.2	0.10	0.00				0.21	0.04			
640		37	0.8	0.8	0.40	0.27				0.21	0.17			
641		38	0.2	0.2	0.10	0.00				0.21	0.04			
642		39	1.0	1.0	0.50	0.52				0.21	0.21			
643		40	0.2	0.2	0.10	0.00				0.21	0.04			
644		41	1.0	1.0	0.50	0.52				0.21	0.21			
645		42	0.3	0.3	0.15	0.01				0.21	0.06			
646		43	1.0	1.0	0.50	0.52				0.21	0.21			
647		44	1.0	1.0	0.50	0.52				0.21	0.21			
648		45	1.0	1.0	0.50	0.52				0.21	0.21			
649		46	0.1	0.1	0.05	0.00				0.21	0.02			
650		47	0.6	0.6	0.30	0.11				0.21	0.13			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
651		48	0.5	0.5	0.25	0.07				0.21	0.11			
652		49	0.8	0.8	0.40	0.27				0.21	0.17			
653		50	0.7	0.7	0.35	0.18				0.21	0.15			
654		51	0.9	0.9	0.45	0.38				0.21	0.19			
655		52	1.0	1.0	0.50	0.52				0.21	0.21			
656		53	1.0	1.0	0.50	0.52				0.21	0.21			
657		54	0.4	0.4	0.20	0.03				0.21	0.08			
658		55	0.2	0.2	0.10	0.00				0.21	0.04			
659		56	5.0	2.5	1.26	4.74				0.21	0.53			
660		57	0.6	0.6	0.30	0.11				0.21	0.13			
661		58	0.9	0.9	0.45	0.38				0.21	0.19			
662		59	0.5	0.5	0.25	0.07				0.21	0.11			
663		60	1.0	1.0	0.50	0.52				0.21	0.21			
664		61	0.2	0.2	0.10	0.00				0.21	0.04			
665		62	0.8	0.8	0.40	0.27				0.21	0.17			
666		63	0.2	0.2	0.10	0.00				0.21	0.04			
667		64	1.0	1.0	0.50	0.52				0.21	0.21			
668		65	0.2	0.2	0.10	0.00				0.21	0.04			
669		66	1.0	1.0	0.50	0.52				0.21	0.21			
670		67	0.3	0.3	0.15	0.01				0.21	0.06			
671		68	1.0	1.0	0.50	0.52				0.21	0.21			
672		69	1.0	1.0	0.50	0.52				0.21	0.21			
673		70	1.0	1.0	0.50	0.52				0.21	0.21			
674		71	0.1	0.1	0.05	0.00				0.21	0.02			
675		72	0.6	0.6	0.30	0.11				0.21	0.13			
676		73	0.5	0.5	0.25	0.07				0.21	0.11			
677		74	0.8	0.8	0.40	0.27				0.21	0.17			
678		75	0.7	0.7	0.35	0.18				0.21	0.15			
679		76	0.9	0.9	0.45	0.38				0.21	0.19			
680		77	1.0	1.0	0.50	0.52				0.21	0.21			
681		78	1.0	1.0	0.50	0.52				0.21	0.21			
682		79	0.4	0.4	0.20	0.03				0.21	0.08			
683		80	0.2	0.2	0.10	0.00				0.21	0.04			
684		81	5.0	2.5	1.26	4.74				0.21	0.53			
685		82	0.6	0.6	0.30	0.11				0.21	0.13			
686		83	0.9	0.9	0.45	0.38				0.21	0.19			
687		84	0.5	0.5	0.25	0.07				0.21	0.11			
688		85	1.0	1.0	0.50	0.52				0.21	0.21			
689		86	0.2	0.2	0.10	0.00				0.21	0.04			
690		87	0.8	0.8	0.40	0.27				0.21	0.17			
691		88	0.2	0.2	0.10	0.00				0.21	0.04			
692		89	1.0	1.0	0.50	0.52				0.21	0.21			
693		90	0.2	0.2	0.10	0.00				0.21	0.04			
694		91	1.0	1.0	0.50	0.52				0.21	0.21			
695		92	0.3	0.3	0.15	0.01				0.21	0.06			
696		93	1.0	1.0	0.50	0.52				0.21	0.21			
697		94	1.0	1.0	0.50	0.52				0.21	0.21			
698		95	1.0	1.0	0.50	0.52				0.21	0.21			
699		96	0.1	0.1	0.05	0.00				0.21	0.02			
700		97	0.6	0.6	0.30	0.11				0.21	0.13			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
701		98	0.5	0.5	0.25	0.07				0.21	0.11			
702		99	0.8	0.8	0.40	0.27				0.21	0.17			
703		100	0.7	0.7	0.35	0.18				0.21	0.15			
704														
705	G78.8	1	1.3	1.3	0.65	1.06	7.24	7.94		0.19	0.25	0.15	0.09	0.63
706		2	0.4	0.4	0.20	0.03				0.19	0.08			
707		3	0.4	0.4	0.20	0.03				0.19	0.08			
708		4	1.1	1.1	0.55	0.69				0.19	0.21			
709		5	1.2	1.2	0.60	0.87				0.19	0.23			
710		6	0.5	0.5	0.25	0.07				0.19	0.10			
711		7	0.6	0.6	0.30	0.11				0.19	0.11			
712		8	0.1	0.1	0.05	0.00				0.19	0.02			
713		9	1.0	1.0	0.50	0.52				0.19	0.19			
714		10	0.2	0.2	0.10	0.00				0.19	0.04			
715		11	0.2	0.2	0.10	0.00				0.19	0.04			
716		12	1.3	1.3	0.65	1.06				0.19	0.25			
717		13	0.8	0.8	0.40	0.27				0.19	0.15			
718		14	0.8	0.8	0.40	0.27				0.19	0.15			
719		15	2.5	1.8	0.89	2.24				0.19	0.34			
720														
721		1	7.0	3.0	1.49	6.74	8.64			0.19	0.57	0.12	0.14	1.22
722		2	1.5	1.4	0.69	1.24				0.19	0.26			
723		3	0.5	0.5	0.25	0.07				0.19	0.10			
724		4	0.1	0.1	0.05	0.00				0.19	0.02			
725		5	0.1	0.1	0.05	0.00				0.19	0.02			
726		6	0.5	0.5	0.25	0.07				0.19	0.10			
727		7	0.3	0.3	0.15	0.01				0.19	0.06			
728		8	0.2	0.2	0.10	0.00				0.19	0.04			
729		9	0.1	0.1	0.05	0.00				0.19	0.02			
730		10	0.6	0.6	0.30	0.11				0.19	0.11			
731		11	0.5	0.5	0.25	0.07				0.19	0.10			
732		12	0.8	0.8	0.40	0.27				0.19	0.15			
733		13	0.2	0.2	0.10	0.00				0.19	0.04			
734		14	0.5	0.5	0.25	0.07				0.19	0.10			
735														
736	G78.9	1	3.0	2.0	0.98	2.74	14.21	12.36		0.12	0.23	0.17	0.05	0.29
737		2	2.2	1.7	0.84	1.94				0.12	0.20			
738		3	1.2	1.2	0.60	0.87				0.12	0.14			
739		4	1.3	1.3	0.65	1.06				0.12	0.16			
740		5	2.0	1.6	0.80	1.74				0.12	0.19			
741		6	2.3	1.7	0.86	2.04				0.12	0.21			
742		7	0.8	0.8	0.40	0.27				0.12	0.10			
743		8	0.7	0.7	0.35	0.18				0.12	0.08			
744		9	2.1	1.6	0.82	1.84				0.12	0.20			
745		10	1.8	1.5	0.76	1.54				0.12	0.18			
746														
747		1	2.1	1.6	0.82	1.84	10.50			0.12	0.20	0.16	0.05	0.28
748		2	2.0	1.6	0.80	1.74				0.12	0.19			
749		3	0.8	0.8	0.40	0.27				0.12	0.10			
750		4	3.0	2.0	0.98	2.74				0.12	0.23			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
751		5	1.5	1.4	0.69	1.24				0.12	0.17			
752		6	0.9	0.9	0.45	0.38				0.12	0.11			
753		7	1.3	1.3	0.65	1.06				0.12	0.16			
754		8	1.5	1.4	0.69	1.24				0.12	0.17			
755														
756	G79.2	1	0.9	0.9	0.45	0.38	5.04			0.25	0.23	0.18	0.09	0.49
757		2	0.5	0.5	0.25	0.07				0.25	0.13			
758		3	0.9	0.9	0.45	0.38				0.25	0.23			
759		4	0.3	0.3	0.15	0.01				0.25	0.08			
760		5	0.5	0.5	0.25	0.07				0.25	0.13			
761		6	0.2	0.2	0.10	0.00				0.25	0.05			
762		7	1.1	1.1	0.55	0.69				0.25	0.28			
763		8	1.3	1.3	0.65	1.06				0.25	0.33			
764		9	1.5	1.4	0.69	1.24				0.25	0.35			
765		10	0.9	0.9	0.45	0.38				0.25	0.23			
766		11	0.8	0.8	0.40	0.27				0.25	0.20			
767		12	0.7	0.7	0.35	0.18				0.25	0.18			
768		13	0.6	0.6	0.30	0.11				0.25	0.15			
769		14	0.3	0.3	0.15	0.01				0.25	0.08			
770		15	0.5	0.5	0.25	0.07				0.25	0.13			
771		16	0.6	0.6	0.30	0.11				0.25	0.15			
772														
773	G82.0	1	4.0	2.3	1.13	3.74	8.33	6.70		0.12	0.27	0.14	0.08	0.56
774		2	3.0	2.0	0.98	2.74				0.12	0.23			
775		3	0.8	0.8	0.40	0.27				0.12	0.10			
776		4	0.9	0.9	0.45	0.38				0.12	0.11			
777		5	1.0	1.0	0.50	0.52				0.12	0.12			
778		6	0.9	0.9	0.45	0.38				0.12	0.11			
779		7	0.4	0.4	0.20	0.03				0.12	0.05			
780		8	0.8	0.8	0.40	0.27				0.12	0.10			
781														
782		1	4.5	2.4	1.20	4.24	5.07			0.12	0.29	0.12	0.09	0.75
783		2	0.8	0.8	0.40	0.27				0.12	0.10			
784		3	0.5	0.5	0.25	0.07				0.12	0.06			
785		4	0.6	0.6	0.30	0.11				0.12	0.07			
786		5	0.9	0.9	0.45	0.38				0.12	0.11			
787														
788	G82.1	1	2.0	1.6	0.80	1.74	7.75	8.36		0.12	0.19	0.10	0.05	0.47
789		2	0.9	0.9	0.45	0.38				0.12	0.11			
790		3	0.2	0.2	0.10	0.00				0.12	0.02			
791		4	0.4	0.4	0.20	0.03				0.12	0.05			
792		5	0.5	0.5	0.25	0.07				0.12	0.06			
793		6	1.5	1.4	0.69	1.24				0.12	0.17			
794		7	0.9	0.9	0.45	0.38				0.12	0.11			
795		8	0.7	0.7	0.35	0.18				0.12	0.08			
796		9	0.9	0.9	0.45	0.38				0.12	0.11			
797		10	1.0	1.0	0.50	0.52				0.12	0.12			
798		11	1.1	1.1	0.55	0.69				0.12	0.13			
799		12	1.2	1.2	0.60	0.87				0.12	0.14			
800		13	1.0	1.0	0.50	0.52				0.12	0.12			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
801		14	0.9	0.9	0.45	0.38				0.12	0.11			
802		15	0.2	0.2	0.10	0.00				0.12	0.02			
803		16	0.7	0.7	0.35	0.18				0.12	0.08			
804		17	0.5	0.5	0.25	0.07				0.12	0.06			
805		18	0.6	0.6	0.30	0.11				0.12	0.07			
806														
807		1	8.0	3.2	1.60	7.74	8.97			0.12	0.38	0.10	0.11	1.07
808		2	0.9	0.9	0.45	0.38				0.12	0.11			
809		3	0.8	0.8	0.40	0.27				0.12	0.10			
810		4	0.2	0.2	0.10	0.00				0.12	0.02			
811		5	0.3	0.3	0.15	0.01				0.12	0.04			
812		6	0.6	0.6	0.30	0.11				0.12	0.07			
813		7	0.8	0.8	0.40	0.27				0.12	0.10			
814		8	0.7	0.7	0.35	0.18				0.12	0.08			
815		9	0.2	0.2	0.10	0.00				0.12	0.02			
816														
817	G82.3	1	4.0	2.3	1.13	3.74	4.98	5.11		0.15	0.34	0.11	0.10	0.94
818		2	1.0	1.0	0.50	0.52				0.15	0.15			
819		3	1.0	1.0	0.50	0.52				0.15	0.15			
820		4	0.1	0.1	0.05	0.00				0.15	0.02			
821		5	0.5	0.5	0.25	0.07				0.15	0.08			
822		6	0.2	0.2	0.10	0.00				0.15	0.03			
823		7	0.6	0.6	0.30	0.11				0.15	0.09			
824		8	0.3	0.3	0.15	0.01				0.15	0.05			
825														
826		1	3.5	2.1	1.06	3.24	5.24			0.12	0.25	0.10	0.06	0.62
827		2	0.5	0.5	0.25	0.07				0.12	0.06			
828		3	0.8	0.8	0.40	0.27				0.12	0.10			
829		4	0.4	0.4	0.20	0.03				0.12	0.05			
830		5	1.0	1.0	0.50	0.52				0.12	0.12			
831		6	0.9	0.9	0.45	0.38				0.12	0.11			
832		7	0.9	0.9	0.45	0.38				0.12	0.11			
833		8	0.8	0.8	0.40	0.27				0.12	0.10			
834		9	0.5	0.5	0.25	0.07				0.12	0.06			
835		10	0.3	0.3	0.15	0.01				0.12	0.04			
836														
837	G84.9	1	1.0	1.0	0.50	0.52	3.80	5.15		0.12	0.12	0.12	0.05	0.41
838		2	0.9	0.9	0.45	0.38				0.12	0.11			
839		3	0.5	0.5	0.25	0.07				0.12	0.06			
840		4	0.8	0.8	0.40	0.27				0.12	0.10			
841		5	1.0	1.0	0.50	0.52				0.12	0.12			
842		6	2.3	1.7	0.86	2.04				0.12	0.21			
843														
844		1	5.0	2.5	1.26	4.74	6.50			0.12	0.30	0.12	0.08	0.66
845		2	1.0	1.0	0.50	0.52				0.12	0.12			
846		3	1.0	1.0	0.50	0.52				0.12	0.12			
847		4	0.8	0.8	0.40	0.27				0.12	0.10			
848		5	0.6	0.6	0.30	0.11				0.12	0.07			
849		6	0.8	0.8	0.40	0.27				0.12	0.10			
850		7	0.5	0.5	0.25	0.07				0.12	0.06			

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Lt. Blue	Coastal Zone studies
Dk. Green	Geochemical and geophysical studies
Dk. Blue	Hydrology
Olive	Economic geology
	Mining directory
Yellow	Environmental studies
	Engineering studies
Dk. Orange	Bibliographies and lists of publications
Brown	Petroleum and natural gas
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