UNITED STATES
DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

AGE, MINERALOGY, PHYSICAL PROPERTIES, AND GEOCHEMISTRY OF DREDGE SAMPLES FROM THE BERING SEA CONTINENTAL MARGIN

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BARTLETT addenda

INTRODUCTION

During the summer of 1978 the U.S. Geological Survey dredged 20 sites along the Bering Sea continental margin (see Fig. 1). Seismic reflection data were correlated with dredge locations using a time/depth recorder (Fig. 2). Over four tons of rocks were recovered at the 20 successful sites (Fig. 3; Table 1) and approximately 800 lbs. of rock were retained for analysis. Analyses of a few samples collected in 1970 are also included here. This report supercedes Marlow and others (1979).

ANALYSES

The dredge samples were analyzed for mineralogy, geochemistry, physical properties, and age (Table 2). Mineralogical studies included modal analysis of thin sections (Tables 3 and 4),and an examination of heavy and light mineral fractions that had been separated from disaggregated sedimentary rocks (Tables 5 and 6). X-ray diffraction analyses were performed on clay (<2μ) fractions from sedimentary samples (Table 7).

Geochemical studies of sedimentary rocks consisted of measuring 26 elements by quantitative emission spectroscopy (Table 8). Instrumental neutron activation analysis (INAA), X-ray fluorescence, emission spectroscopy, and partial chemical analysis for CO_2, H_2O^+, H_2O^-, and FeO were performed on igneous rock samples (Tables 9 and 10). Sedimentary samples were assayed for total carbon content, $CaCO_3$, and organic carbon content

(Table 11). Several of those with high organic carbon content were further analyzed by pyrolysis in order to measure thermal maturity.

The studies of physical properties included determinations of bulk density (Table 12) and grain size distribution (Table 13). Porosity and permeability measurements on a few sedimentary rock samples were performed by Core Labs, Inc. (Table 14).

Dating of the dredge samples was by microfossils, pelecypod assemblages, and K-Ar radiometric dating (Dalrymple and Lanphere, 1969) (Table 15). In general, foraminifera were scarce and not highly diagnostic, whereas useful diatom assemblages were common and were the basis for the bulk of the age calls. Some samples, too well consolidated for mechanical microfossil extraction, yielded diagnostic forms upon treatment with hydrofloric acid; thus the remainder of the age calls were based on resistant pollen grains and spores, coccoliths, silicoflagellates, and radiolarian biostratigraphy.

METHODS AND PROCEDURES

Mineralogy

Thin sections were prepared from selected igneous and sedimentary samples and modal analyses with a minimum of 500 counts, were done using the line method (Galehouse, 1971). Disaggregation of sedimentary samples, for density fractionation was accomplished in an aqueous $NaPO_4$ solution to assist clay

dispersal. Mechanical assistance varied, as required, from simple stirring to ultrasonic agitation. A fine sand fraction (64 μ to 88 μ) was separated by sieving, then dried, and further fractionated gravimetrically using dilute tetrabromoethane (specific gravity of 2.85) Grain mounts were made, and at least 300 points were counted using the line method (Galehouse, 1971). Clay fractions (less than 2μ diameter) were prepared and x-rayed on a Picker XRD following the procedures of Hein and others (1976). Relative percents of the different clay minerals were estimated using Biscaye's (1965) method.

Geochemistry

Quantitative 26 element emission spectroscopy is discussed in Bastron, and others (1960). Instrumental neutron activation analysis is treated in Gijbles and Hertogen (1971) and in Gordon, et al. (1969). Semi-quantitative 43 element emission spectroscopy and X-ray fluorescence are discussed by Meyers and others (1961) and Abbey (1972), respectively. The techniques for partial chemical analyses are discussed at length in Maxwell (1968).

Determination of the total carbon content of our samples was accomplished using an induction furnace, a LECO WR-12 carbon analyzer, and Tillman's (1977) method. In most cases we analyzed three splits of each sample and averaged the results. In some instances results varied sufficiently to warrant assays on five splits, with the high and low values excluded from the final

average. The procedure we used for measuring the amount of inorganic carbon (carbonate) is similar to that of Kolpack and Bell (1968) - a gasometric determination. Splits were acidified with excess HCl and the evolved gases bubbled through concentrated H_2SO_4 to remove water, using oxygen as a carrier. A LECO WR-12 was then used to measure the amount of CO_2 given off. Three to five splits were measured, as required. Pyrolitic hydrocarbon yields were determined by George Claypool following the method described in Merewether and Claypool (1980).

Physical Properties

Horizontal porosities and permeabilities in helium were measured by Core Labs, Inc. Sample preparation for grain size analyses followed the same procedures used to determine the heavy/light mineralogies. Silt and clay fractions were separated by wet sieving and measured with a hydrophometer using Jordan's (1971) method. Gravel was screened and weighed directly and sand fractions were analyzed using a two meter settling tube (Thiede and others, 1976). These data were merged with the silt and clay data and statistical parameters were calculated following the methods of Folk and Ward (1957). Bulk density was measured by weighing samples and observing their displacement of water.

ACKNOWLEDGMENTS

Preliminary lithologic identificaions were done by David Scholl and Hugh McLean. Age calls were in part based on fossil identifications by David Bukry (coccoliths), David L. Jones (pelecypods), John W. Miller (pelecypods), Louie Marincovich (pelecypods), and Stanley A. Kling (radiolaria). Paula Quinterno assisted in the processing and inspection of samples for microfossils. George Claypool performed pyrolytic hydrocarbon analyses. We thank Hugh McLean for reviewing the manuscript and we also thank Tracy Vallier for the lithologic descriptions, as well as his guidance and advice.

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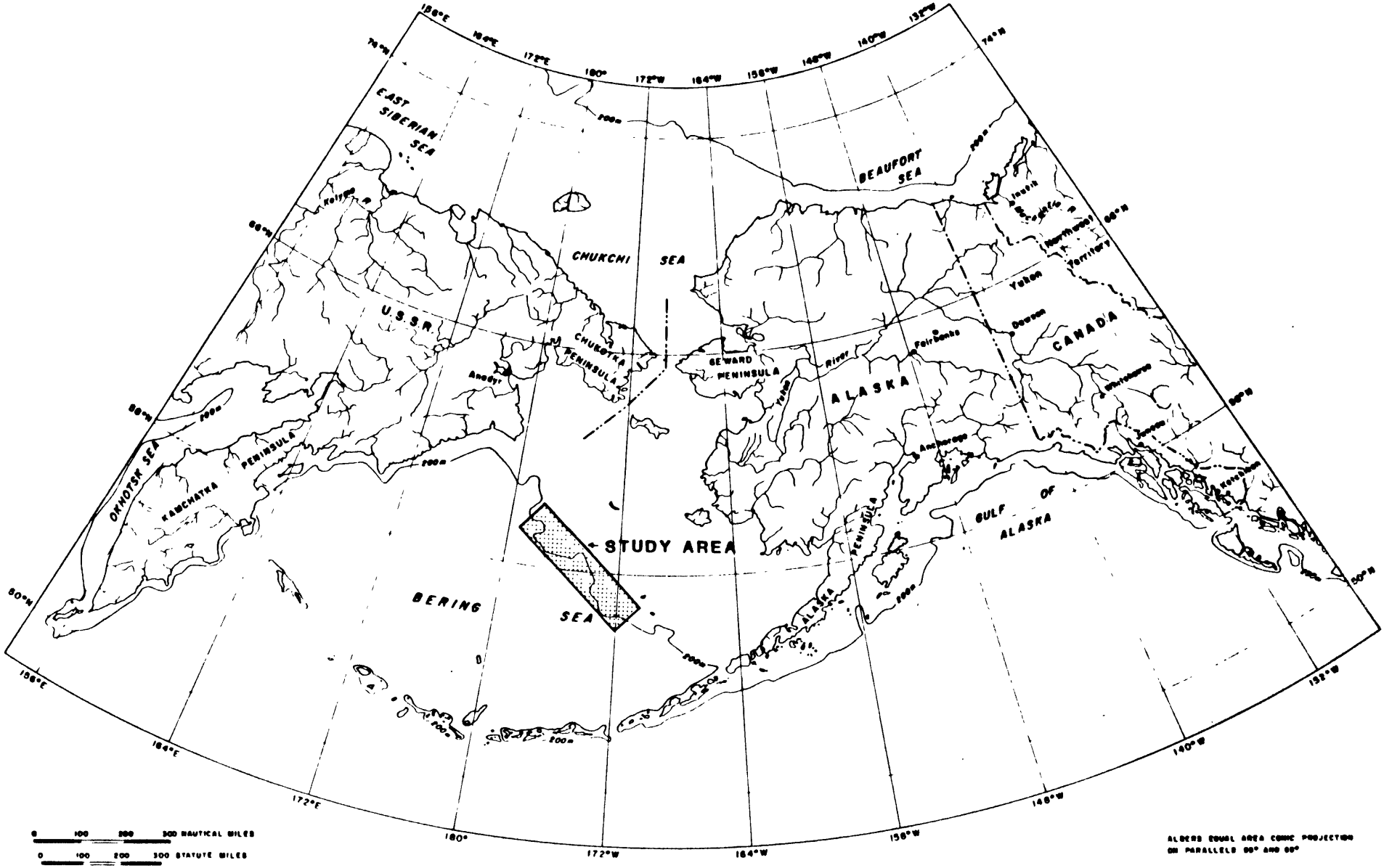

Figure 1. Location of study area along the Bering Sea continental margin.

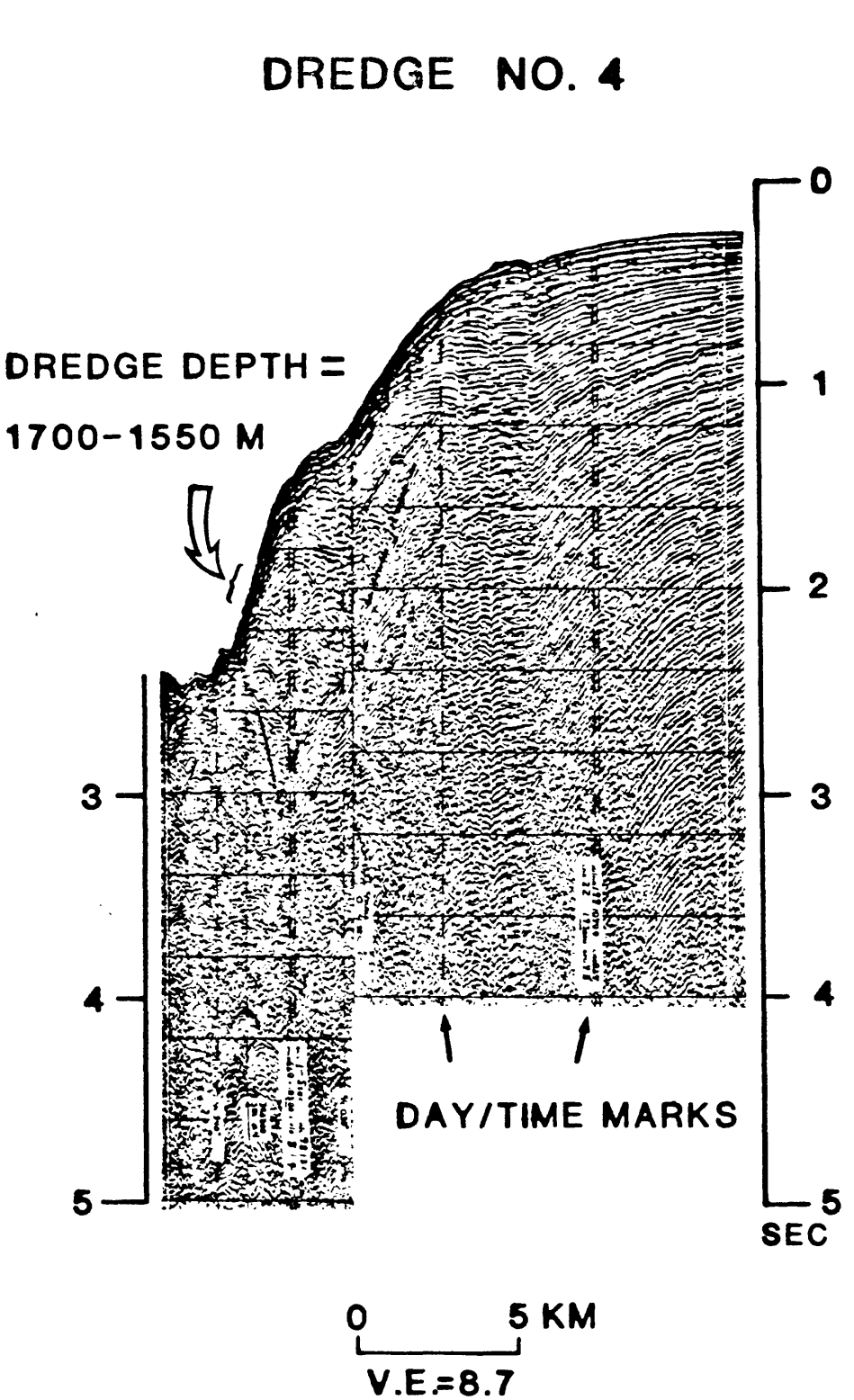

Figure 2. Dredge site-seismic profile correlation. The Julian day and time logged by the time/depth recorder corresponds to a specific latitude and longitude in the navigation data set. By comparison against the seismic reconnaissance navigation, this position can be converted into a unique Julian day and time on the seismic profile. The dredge depth is read directly from the recorder's log.

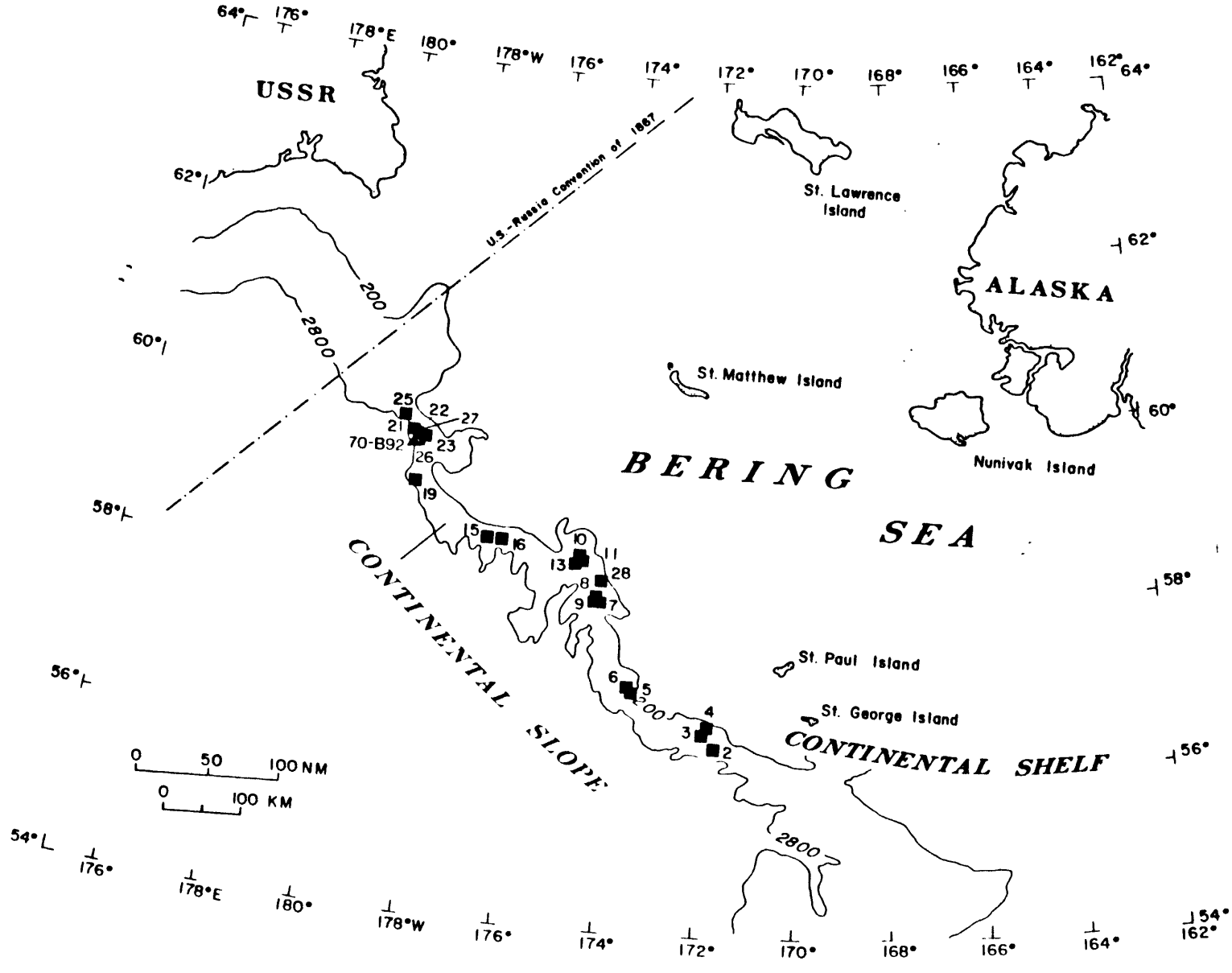

Figure 3. Location of successful dredge stations.

Table 1. Dredge station locations

Station	Latitude	Longitude	Depth (meters)
L5-78-BS 1		No Recovery	
1A		No Recovery	
2	56°12.3'N	171°42.2'W	2500-2700
3	56°22.0'N	171°53.4'W	2000-2200
4	56°25.6'N	171°53.5'W	1550-1700
5	56°51.1'N	173°32.7'W	1500-1700
6	56°50.5'W	173°31.4'W	1600-1850
7	57°53.0'N	174°22.3'W	1600-1900
8	57°53.1'N	174°22.6'W	1250-1500
9	57°52.0'N	174°25.0'W	1200-1250
10	58°20.2'N	174°51.7'W	1450-1800
11	58°20.1'N	174°51.6'W	1400-1550
12		No Recovery	
13	58°19.73'N	174°51.6'W	750-1100
14		No Recovery	
15	58°27.5'N	176°51.9'W	950-1100
16	58°28.6'N	176°36.5'W	1800-2050
17		No Recovery	
18		No Recovery	
19	59°03.3'N	178°43.1'W	1500-2500
20		No Recovery	
21	59°38.5'N	178°52.2'W	1800-2600
22	59°36.9'N	178°49.2'W	1500-2200
23		No Recovery	
24		No Recovery	
25	59°47.2'N	179°08.3'W	2000-2800
26	59°33.8'N	178°47.4'W	1800-2500
27	59°36.2'N	178°38.8'W	1750-1800
28	58°06.1'N	174°18.3'W	800-1650
29		No Recovery	
70-B92*	59°33.1'N	178°54.7'W	2400-2600

*From Marlow and others (1976)

Table 2. Analyses completed on dredge haul rocks, cruises L5-78-BS and 70-B92
(See footnotes, last page of table, for explanations of abbreviations.)

Sample[1]	Lithology[2]	Age	Method[3]	Mineralogy[4]				Geochemistry[5]				Physical properties[6]		
				M.A.	H	L	X-ray	X	E	N	C	Por/perm	GZ	BD
L5-78-BS														
2-1	Sandy mudstone	Late Oligocene	D		x	x	x				x		x	
2-2	Volc. sandstone	--									x			x
2-3	Mudstone	Paleocene (?)	F				x				x		x	
2-4	Diat. mudstone	Late Oligocene	D		x		x		x		x	x		
2-5	Diat. sandy mudstone	Oligocene or early Miocene	D,Y		x		x				x	x		
2-6	(Mudstone)	Oligocene or early Miocene	D,Y				x		x		x			
2-8	Glauc. sandy mudstone	Late Oligocene	D		x	x						x	x	
2-9	Clayey diatomite	Late Oligocene	D				x				x			
2-10	(Not determined)	--					x				x			
2-11	Diat. calcareous mudstone	Late Oligocene	D				x				x	x		
3-1	Volc. sandstone	--												x
3-4	Basalt	--		x				x	x	x				
4-1	Mudstone	Oligocene or early Miocene	D,Y				x		x		x			
4-2	Volc. sandstone	--		x					x		x			x
4-3	(Mudstone)	Early Oligocene	D									x		
4-4	Clayey limestone	--									x			
4-5	(Mudstone)	Oligocene or early Miocene	D,Y				x				x			

Table 2. (Continued)

Sample[1]	Lithology[2]	Age	Method[3]	Mineralogy[4]				Geochemistry[5]				Physical properties[6]		
				M.A.	H	L	X-ray	X	E	N	C	Por/perm	GZ	BD
L5-78-BS														
4-6	Mudstone	Late Oligocene(?)	D		x						x			
4-7	Siltstone	--							x		x			
5-1	Diat. mudstone	Latest Oligocene	D		x	x	x		x		x		x	
5-2	Volc. sandstone	Eocene	Y	x	x	x								
5-3	Mudstone	Late Pliocene	D								x	x		
5-4	(Diat. mudstone)	Late Oligocene	D				x				x			
5-5	Volc. sandstone	Late Jurassic (Kimmeridgian)	P	x					x		x			x
5-7	Clayey limestone	Late middle Miocene	D								x			
5-10	Andesite tuff	Early Miocene or Late Oligocene	D	x	x	x	x				x	x	x	x
6-2	Calc. volc. sandstone	--		x	x						x			
6-3	Sandy limestone	Late Quaternary	D	x	x	x	x				x			
6-5	Volc. sandstone	Quaternary		D										x
6-7	Silty sandstone	Late Oligocene or early Miocene(?)	D		x	x	x				x	x	x	
6-12	(Diat. siltstone)	Late Oligocene to early Miocene(?)	D,Y											
7-3	Diat. mudstone	Early middle Miocene	D				x		x			x	x	
7-3a	Mudstone	--					x				x		x	
7-3b	(Diat. mudstone)	--					x				x		x	
7-5	Mudstone	Middle middle Miocene	D											

Table 2 (Continued)

Sample[1]	Lithology[2]	Age	Method[3]	Mineralogy[4]				Geochemistry[5]				Physical properties[6]		
				M.A.	H	L	X-ray	X	E	N	C	Por/perm	GZ	BD
L5-78-BS														
8-1	(Diat. mudstone)	Latest Miocene or Pliocene(?)	D,Y		x	x	x				x			
8-6	Diat. mudstone	Middle middle Miocene	D		x		x				x			
8-8	Sandy siltstone	Quaternary	D											x
9-1	Diat. mudstone	Latest middle Miocene	D		x		x				x			
9-2	Glauc. diat. mudstone	Latest middle Miocene	D				x		x		x	x		
10-2	Spilite	--		x				x	x	x				
10-3	Spilite	--		x				x	x	x				
11-1	Clayey limestone	Middle middle Miocene	D				x					x		
11-2	Clayey limestone	--									x			
13-1	(Sandstone)	Middle Pliocene	D											
13-2	(Muddy Sandstone)	Late Pliocene	D				x				x			x
13-3	Sandstone	--												x
13-5	Volcanic breccia (tuff?)	Middle Pliocene	D											
13-6	(Pebbly sandstone)	Late late Miocene to early Pliocene	D											
13-9	(Pebbly sandstone)	Late Pliocene	D				x				x			

Table 2. (Continued)

Sample[1]	Lithology[2]	Age	Method[3]	Mineralogy[4]				Geochemistry[5]				Physical properties[6]		
				M.A.	H	L	X-ray	X	E	N	C	Por/perm	GZ	BD
L5-78-BS														
15-3	Basalt	Early Eocene (minimum)	K	x				x	x	x				
15-5	Basalt	--		x				x	x	x				
15-6	Basalt	--		x				x	x	x				
15-7	Basalt	--		x				x	x	x				
16-1	(Mudstone)	--					x				x			
16-3	Tuff	--		x			x				x		x	
16-4	Volc. sandstone	--									x			
16-6	Clayey limestone	--					x				x			x
16-7	Tuff	--									x			
16-9	Mudstone	Late early or early middle Eocene	S,F								x			
16-12	(Mudstone)	Eocene (?)	F				x				x	x		
16-14	(Mudstone)	Late (?) Eocene	F											
19-2	Diat. mudstone	Late Quaternary	D				x				x			
21-1	Siltstone	--				x	x				x			
21-2	Volc. sandstone	Quaternary	D								x			x
22-1	Sandstone	--											x	
22-2	Glauc. sandstone	Late Cretaceous to Recent	D	x								x		
22-3	(Pebbly sandstone)	Middle Miocene	D											

Table 2. (Continued)

Sample[1]	Lithology[2]	Age	Method[3]	Mineralogy[4]				Geochemistry[5]				Physical Properties[6]		
				M.A.	H	L	X-ray	X	E	N	C	Por/Perm	GZ	BD
L5-78-BS														
22-4	Siltstone	Late Miocene or Quaternary, Campanian or Maestrichtian	D, S, Y								x			x
22-5	Tuff. limestone	--									x			
22-6	Clayey limestone	Campanian or Maestrichtian	Y											x
22-7	Clayey limestone	Late Jurassic	S								x			x
22-10	Rhyolite	--		x				x	x	x				
22-11	Rhyolite	--		x				x	x	x				
22-15	(Coarse-grained sandstone)	--			x	x								
22-18	Volc. sandstone	--											x	
25-2	Tuff	--			x	x								
25-4	(Coarse grained sandstone)	Quaternary	D											
26-1	Volc. sandstone	Early Piocene	D	x	x	x	x		x		x		x	
26-2	Mudstone										x			
26-4	Tuff										x			
26-6	Limestone	Paleogene (Paleocene?)	S,Y											
27-1	Sandy siltstone	Cretaceous, Campanian or Maestrichtian	R,Y									x		x
27-2	Tuff	--		x	x	x			x		x			x
27-3	Volc. sandstone			x							x			x

Table 2. (Continued)

Sample[1]	Lithology[2]	Age	Method.[3]	Mineralogy[4]				Geochemistry[5]				Physical Properties[6]		
				M.A.	H	L	X-ray	X	E	N	C	Por/Perm	GZ	BD
L5-78-BS														
27-4	Volcanic sandstone	Paleogene (Paleocene?)	S,Y											
27-5	Volc. sandstone										x		x	
27-6	(Mudstone)	--					x		x		x			
28-1	Diat. mudstone	Late Miocene	D				x				x	x		
28-2	Diat. mudstone	Early Pliocene	D											
28-3	Diat. calc. sandstone	Latest Miocene or earliest Pliocene	D								x			
28-5	Clayey limestone	--									x			
28-6	Clayey limestone	Late(?) Pliocene to Holocene	D,P											
70-B92-														
3S3-a	Brecciated mudstone	Paleocene to Eocene	S,Y								x	x		x
3S5-a	Conglomerate	Paleocene to Eocene	S,Y								x	x		x
3S6-a	Mudstone	Paleocene to Eocene	S,Y								x			

1) L5-78-BS designates 1978 R/V S. P. LEE cruise; 70-B92 designates 1970 USNS BARTLETT cruise.
2) Parentheses - lithology determined from hand specimen; all others from thin sections.
3) D, diatoms; F, foraminifera; P, pelecypods; K, potassium-argon dating; S, silicoflagellates; R, radiolarians; Y, palynomorphs (pollen, spores, and dinoflagellate cysts).
4) M.A., modal analyses of thin sections; H, L, heavy-light grain counts; X-ray is of clays.
5) X, X-ray flourescence; E, emission spectroscopy; N, instrumental neutron activation analysis; C, carbon/carbonate analysis.
6) Por/perm, porosity and permeability; GZ, grain size; BD, bulk density.

Table 3. Major components (%) in thin sections of sedimentary rocks

Sample	Points Counted	Feld.	Quartz	Amph.	Opaque	Glass Volc.	Glass Brown	Rk. frags. Volc.	Rk. frags. Met.	Rk. frags. Sed.	CO_3	Glauc.	Clay	Matrix	Remarks
L5-78-BS															
4-2 (Volc. sandstone)	514	33	2	--	5	2	--	31	6	1	3	--	11	--	5% lt. green unknown. Sample altered. T[1] biotite.
5-2 (Volc. sandstone)	503	28	--	1	6	6	--	50	--	--	--		--	--	25% fecal pellets. Matrix = clay, glass. Glass rounded, fresh. $T_{epidote, biotite}$.
5-5 (Volc. sandstone)	504	20	1	1	7	1	--	60	T	--	T	--	--	10	Matrix = clay. $T_{biotite}$.
5-10 (Andesite tuff)	506	6	--	--	1	2	14	5	--	--	--	--	--	73	Tuffaceous groundmass w/clasts of tuff = glass, op[2], plag, (qtz?). $T_{epidote}$.
6-2 (Calc. volc. sandstone)	514	10	--	1	5	1	3	7	--	2	4	--	--	66	Groundmass = CO_3. CO_3 replacing feldspar.
6-3 (Sandy limestone)	509	10	--	1	2	5	T	--	--	--	3	--	--	79	Groundmass = CO_3.
16-3 (Tuff)	506	9	--	T	17	11	--	19	--	--	--	--	26	17	Groundmass = clay, glass.
22-2 (Glauc. sandstone)	494	5	8	T	1	2	--	36	2	--	--	17	--	26	Matrix = glass, op, (plag, qtz?). T_{garnet}.
26-1 (Volc. sandstone)	508	17	1	1	1	33	--	37	T	5	1	--	--	--	3% zeolite. 65% of glass, 33% of VRF[3] are fresh. $T_{epidote}$.
27-2 (Tuff)	512	22	--	T	5	9	--	44	3	9	1	--	--	8	Matrix = clay, glass, plag. Sample altered.
27-3 (Volc. sandstone)	506	11	10	--	5	4	--	63	--	--	--	1	6	--	$T_{epidote}$.

1) T = trace amount
2) Op = opaque minerals
3) VRF = volcanic rock fragments

Table 4. Major components (%) in thin sections of igneous rocks[3)]

Sample	Points Counted	Plagioclase Phenos.	Plagioclase Laths	Opaque	Cpx.	Ol.	Glass	Biot.	Ep.	Chl.	Leuc.	Clay	Remarks
L5-78-BS													
3-4 (Basalt)	488	27	43	7	18	2	--	--	--	--	--	2	~10% vesicles.
10-2 (Spilite)	519	3	52	9	--	--	5	--	15	15	2	--	Ep. replacing plag., chl. replacing glass.
10-3 (Spilite)	532	--	52	18	1	--	1	--	14	13	1	--	As above.
15-3 (Basalt)	517	17	65	9	3	--	1	--	--	--	--	6	Plag. laths = microlites.
15-5 (Basalt)	507	21	37	4	14	T	--	--	--	--	--	22	1% CO_3; 3% of clay replacing olivine.
15-6 (Basalt)	500	23	44	9	13	--	--	--	--	--	--	11	~2% vesicles.
15-7 Basalt)	524	25	54	5	7	--	1	--	--	--	--	7	~3% vesicles. Clay replacing cpx and olivine.
22-10 (Rhyolite)	500	88 groundmass[1)]		--	--	--	9	--	--	--	2		1% muscovite.
22-11 (Rhyolite)	508	86 groundmass[2)]		--	--	--	4	1	9	--	--		Biotite pale brown to clear.

1) 63% plagioclase
25% quartz
2-5% clay
7-10% opaque

2) 66-78% plagioclase
10-20% quartz
5-7% opaque
7% glass

3) Cpx = clinopyroxene
Ol. = olivine
Ep. = epidote
Chl. = chlorite
Leuc. = leucoxene

Table 5. Heavy mineral data %

Sample	Points Counted	Amph.	Cpx.	Opx.	Ep.	Opaque	Volc. Rk.Frag.	Altered Rk.Frag.	Fine gr. Rk.Frag.	Meta-volc.	CO_3 Frag.	Bas. Glass	Biot.	Garnet	Chl.	Unknown	Other
L5-78-BS																	
2-1 (Sandy mudstone)	314	57.3	8.3	2.9	5.1	11.1	1.0	3.2	3.8	--	--	--	T	1.6	1.6	3.5	T* sphene
2-4 (Diat. mudstone)	346	34.4	8.7	4.3	5.5	14.7	5.8	9.2	4.3	--	--	--	T	2.0	8.7	2.3	T sphene, glauc.
2-5 (Diat. sandy mudstone)	456	23.0	3.1	1.3	0.7	62.9	0.7	4.4	--	--	--	--	--	0.2	1.5	2.2	--
2-8 (Glauc. sandy mudstone)	343	56.8	9.9	3.2	4.7	6.7	1.5	7.3	--	--	--	--	0.3	0.3	6.1	2.6	T zircon, gabbro
4-6 (Mudstone)	335	38.2	0.3	1.8	2.1	27.8	0.9	11.9	--	8.4	--	--	--	0.6	3.3	4.5	T zircon, lampb.
5-1 (Diat. mudstone)	344	42.7	14.5	1.7	3.5	10.2	2.0	8.4	--	--	--	--	1.2	2.0	7.0	6.4	T sphene, zircon
5-2 (Volc. sandstone)	422	25.6	4.3	0.2	0.9	60.4	0.2	3.6	--	--	--	--	0.9	--	0.9	1.9	T zircon 1.0 lampb.
5-10 (Andesite tuff)	320	45.9	11.9	1.2	9.2	11.3	4.7	3.1	--	--	--	--	2.2	1.9	4.7	5.9	--
6-2 (Calc. volc. sandstone)	301	46.5	6.3	0.3	4.6	21.9	2.6	4.3	--	3.0	--	--	2.7	1.3	3.0	2.3	--
6-3 (Sandy limestone)	302	52.6	8.9	1.3	1.9	11.3	--	9.9	0.3	1.0	--	--	1.0	0.3	6.6	4.6	--
6-7 (Silty sandstone)	360	55.6	7.2	1.4	3.6	13.1	--	8.3	--	1.1	--	--	0.6	2.2	2.2	4.7	T sphene

* T = trace amount

Table 5. (Continued)

Sample	Points Counted	Amph.	Cpx.	Opx.	Ep.	Opaque	Volc. Rk.Frag.	Altered Rk.Frag.	Fine gr. Rk.Frag.	Meta- volc.	CO_3 Frag.	Bas. Glass	Biot.	Garnet	Chl.	Unknown	Other
L5-78-BS (Continued)																	
8-1 (Diat. mudstone)	323	56.7	2.8	5.3	1.9	12.7	--	6.5	--	6.0	--	--	0.3	2.8	1.9	3.7	--
8-6 (Diat. mudstone)	330	60.6	3.0	0.3	3.6	12.7	0.3	5.4	--	7.6	--	--	0.3	1.5	1.2	3.3	--
9-1 (Diat. mudstone)	301	68.1	0.7	1.0	4.6	9.0	--	3.3	0.3	7.3	--	--	T	1.3	1.3	2.3	T_{zircon}
22-15 (Coarse-grained sandstone)	322	4.0	3.1	0.6	6.8	61.5	6.8	--	--	10.2	--	--	--	0.9	4.7	1.2	--
25-2 (Tuff)	312	44.9	1.6	3.2	0.3	9.3	1.9	7.4	--	8.3	0.3	10.3	--	2.9	0.6	4.5	--
26-1 (Volc. sandstone)	363	41.0	3.3	0.8	1.7	27.0	1.9	4.4	--	3.6	10.7	--	0.3	1.6	1.4	1.1	1.0_{zircon}
27-2 (Tuff)	303	8.8	0.7	--	5.6	74.9	4.3	0.7	--	--	--	--	--	2.6	1.6	0.3	T_{zircon}

* T = Trace amount

Table 6. Light mineral data (%)

Sample	Points Counted	Feldspar	Altered Feldspar	Quartz	Volc. Glass	Alt. Volc. Glass	Volc. Rk.Frag.	Volc. Rk. Frag.w/Glass	Fine Gr. Sed.	CO_3 Frag.	Altered Unknown	Unknown	Other
L5-78-BS													
2-1 (Sandy mudstone)	351	43.3	11.1	--	0.6	2.8	--	3.1	35.3	--	--	2.6	1.1
2-8 (Glauc. sandy mudstone)	413	57.6	14.3	1.2	0.7	15.3	8.7	0.2	1.2	0.2	--	0.5	--
5-1 (Diat. mudstone)	337	22.0	10.4	--	--	12.5	1.5	0.6	52.2	--	--	0.3	0.6
5-2 (Volcanic mudstone)	457	11.2	10.9	--	--	53.8	--	21.7	--	--	1.3	--	1.1
5-10 (Andesite tuff)	305	54.4	5.6	--	1.6	29.2	--	8.2	--	--	--	0.7	0.3
6-3 (Sandy limestone)	328	18.0	6.7	0.3	--	12.2	2.7	--	17.1	42.4	0.3	0.3	--
6-7 (Silty sandstone)	358	42.2	10.1	1.1	--	23.5	--	4.2	15.6	--	--	2.5	0.8
8-1 (Diat. mudstone)	373	30.8	5.4	0.3	--	33.0	1.3	--	27.6	--	--	0.3	1.3

Table 6. (Continued)

Sample	Points Counted	Feldspar	Altered Feldspar	Quartz	Volc. Glass	Alt. Volc. Glass	Volc. Rk.Frag.	Volc. Rk. Frag.w/Glass	Fine Gr. Sed.	CO_3 Frag.	Altered Unknown	Unknown	Other
L5-78-BS (Continued)													
21-1 (Siltstone)	304	29.9	10.5	--	--	51.6	--	7.9	--	--	--	--	--
22-15 (Coarse grained sandstone)	319	19.4	6.0	--	--	59.6	2.8	7.2	0.3	3.1	--	0.9	0.6
25-2 (Tuff)	333	3.3	0.3	--	95.5	0.9	--	--	--	--	--	--	--
26-1 (Volcanic sandstone)	298	24.2	6.0	--	1.0	60.4	--	6.4	1.7	--	--	0.3	--
27-2 (Tuff)	370	48.9	3.2	--	--	37.0	0.3	10.3	--	--	--	--	0.3

Table 7. Clay mineral data

Sample No.	% Kaol.+Chlor.	% Kaolinite	% Chlorite	% Illite	% Smectite	% Illite In Mixed Layer
L5-78-BS						
2-1 (Sandy mudstone)	27	3	24	26	47	69
2-3 (Mudstone)	5	0	5	2	93	89
2-4 (Diat. mudstone)	17	5	12	17	66	70
2-5 (Diat. sandy mudstone)	14	5	9	20	66	75
2-6 (Mudstone)	21	8	13	49	30	59
2-9 (Clayey diatomite)	15	4	11	16	69	65
2-10 (Not determined)	17	4	13	18	65	70
2-11 (Diat. calc. mudstone)	16	2	14	16	68	62
4-1 (Mudstone)	14	5	9	12	74	70
4-5 (Mudstone)	18	4	14	17	65	65
5-1 (Diat. mudstone)	26	9	17	32	42	62
5-4 (Diat. mudstone)	24	8	16	18	58	70
5-10 (Andesite tuff)	20	5	15	18	62	70
6-3 (Sandy limestone)	33	8	25	48	19	56
6-7 (Silty sandstone)	23	8	15	19	58	70

Table 7. Continued)

Sample No.	% Kaol.+Chlor.	% Kaolinite	% Chlorite	% Illite	% Smectite	% Illite In Mixed Layer
L5-78-BS (Continued)						
7-3 (Diat. mudstone)	7	2	5	4	89	84
7-3a (Mudstone)	13	4	9	15	72	75
7-3b (Diat. mudstone)	8	3	5	7	85	85
8-1 (Diat. mudstone)	14	4	10	23	63	75
8-6 (Diat. mudstone)	19	6	13	21	60	70
9-1 (Diat. mudstone)	21	7	14	22	57	70
9-2 (Glauc. diat. mudstone)	19	6	13	19	62	70
11-1 (Clayey limestone)	23	6	17	37	49	56
13-2	28	7	21	50	21	75
13-9 (Pebbly sandstone)	12	3	9	20	68	75
16-1 (Mudstone)	14	5	9	9	77	76
16-3 (Tuff)	1	0	1	0	99	96
16-6 (Clayey limestone)	9	2	7	3	88	69
16-12 (Mudstone)	10	3	7	8	82	75
19-2 (Diat. mudstone)	24	5	19	44	32	75

Table 7. (Continued)

Sample No.	% Kaol.+Chlor.	% Kaolinite	% Chlorite	% Illite	% Smectite	% Illite In Mixed Layer
21-1 (Sandstone)	34	5	29	20	46	65
26-1 (Volc. sandstone)	5	0	5	4	91	89
27-6	12	1	11	12	76	75
28-1 (Diat. mudstone)	23	6	17	37	40	57

Table 8. Minor and trace element geochemistry of sedimentary rocks, L5-78-BS

Element (ppm)	2-4	2-6	4-1	4-2	4-7	5-1	5-5	7-3	9-2	26-1	27-2	27-6
*Ti	0.41	0.66	0.59	0.52	0.63	0.51	0.69	0.33	0.37	0.63	0.83	0.71
Mn	910	190	1300	910	270	310	640	180	180	310	300	270
B	220	200	280	23	80	160	30	180	210	110	57	160
Ba	510	730	550	570	670	680	610	430	550	470	440	540
Co	11	16	11	21	18	13	17	8	8	18	19	19
Cr	71	83	83	35	36	97	25	55	74	56	48	86
Cu	32	47	50	38	43	30	59	30	37	32	30	57
Ni	23	47	32	24	21	38	16	20	25	22	22	37
Sc	13	20	16	22	18	18	22	18	12	20	27	23
Sr	150	150	180	310	300	200	710	120	150	390	430	270
V	96	200	130	180	180	150	160	87	100	155	190	220
Y	26	19	26	19	16	24	28	24	21	30	27	28
Zn	100	140	130	100	110	100	100	69	82	87	120	120
Ga	12	20	18	19	17	15	22	8	10	18	23	21
Yb	2.9	5.2	4.6	4.0	2.8	4.2	4.6	3.4	2.8	4.7	5.4	5.8

*(in wt. %)

Samples were also tested for, but found below detection limits (in parentheses) of:

Ag (2)	Nb (20)
Be (2)	Pb (14)
Cd (14)	Sn (4)
La (14)	Ge (14)
Mo (4)	Li (400)

Table 9. Minor and trace element geochemistry of igneous rocks, L5-78-BS

PPM[1]	Sample No. 3-4 basalt	10-2 spilite	10-3 spilite	15-3 basalt	15-5 basalt	15-6 basalt	15-7 basalt	22-10 rhyolite	22-11 rhyolite
Co	45.75	36.5	35.1	19.75	30.4	37.05	28.1	3.4	3.3
Cs	<0.8	<1.0	<1.0	2.2	0.7	1.25	1.2	0.55	0.8
Hf	3.1	2.3	2.3	3.1	1.95	2.1	2.2	2.15	2.25
Sb	<0.8	0.6	<2.0	0.7	<1.0	0.5,<1.0	0.6	<0.3,0.2	0.15
Ta	1.295	<0.6	<0.6	0.305	0.365	0.38	0.26	0.15	0.16
Th	1.8	0.4	0.6	2.8	1.25	1.25	1.45	1.25	0.95
U	0.5,0.1	0.6	0.5	1.65	0.95	1.45	1.25	0.85	0.75
Zn	102	91	85	108	81	78	129.5	9.5	26.7
SC	23.9	41.90	43.60	22.45	33.2	35.1	29.65	2.225	1.49
La	14	6	6	14	6.5	7.5	12.5	5	4
Ce	29	17	16	32	15.5	17.5	24.5	11	10
Nd	16.5	9	11	21.5	11	12	15.5	6	6
Sm	4.6	4.4	4.0	5.0	2.9	3.45	4.35	1.45	1.4
Eu	1.385	1.29	1.28	1.385	0.885	0.995	1.135	0.44	0.415
Gd	4.4	4.1	3.4	4.6	3.9	2.95	4.3	1.2,<2.0	1.0,<2.0
Tb	.735	0.87	0.81	0.695	0.45	0.55	0.725	0.15	0.115
Ho	0.7	0.8	1.0	1.15	0.55	0.55	1.0	<0.3,<0.4	<0.3
Tm	0.585	0.46	0.66	0.505	0.285	0.48	0.54	0.06	<0.08
Yb	1.9	3.0	2.9	2.5	1.9	2.1	2.45	0.3	0.2
Lu	0.27	0.51	0.45	0.39	0.285	0.325	0.36	0.04	0.03
Sr[2]	406	132	120	524	325	354	396	827	832
Zr[2]	106	78	76	107	63	80	67	78	79
Y[2]	20	25	28	26	21	21	25	5	5
Ba[2]	240	80	104	556	230	236	416	269	280
Nb[2]	24	5	<5	<5	<5	27	32	<5	<5
Rb[2]	8	2	2	50	22	29	20	16	20
B[3]	<10	19	10	36	<10	10	23	<10	<10
Be[3]	2.0	1.4	1.4	2.1	1.6	1.5	1.5	2.0	1.8
Cu[3]	39	20	15	99	92	220	51	4.8	5.1
Pb[3]	47	<10	<10	<10	<10	<10	<10	<10	<10
V[3]	230	400	360	270	270	300	220	35	26

1) Determined by Instrumental Neutron Activation Analysis except where noted by 2) and 3).
2) Determined by X-ray fluorescence
3) Determined by Emission Spectroscopy-Quantitative Direct Reader.

Table 10. Major and minor oxide geochemistry of igneous rocks, L5-78-BS (See Table 7 for modal analyses.)

Oxide (wt. %)	Sample No. 3-4 basalt	10-2 spilite	10-3 spilite	15-5 basalt	15-6 basalt	15-7 basalt	22-10 rhyolite	22-11 rhyolite
SiO_2	49.27	49.31	49.39	51.18	52.43	52.28	71.44	71.04
TiO_2	2.00	1.72	1.71	0.95	1.02	0.84	0.20	0.20
Al_2O_3	15.00	15.85	15.78	17.30	18.54	17.34	16.05	15.83
*Fe_2O_3	4.23	6.35	6.38	3.61	3.66	4.64	0.44	0.61
FeO	6.19	4.33	4.30	4.22	2.80	5.49	0.82	1.16
CaO	9.17	7.47	8.15	10.41	10.65	9.30	2.48	2.47
MgO	8.50	4.11	4.40	6.30	4.93	4.71	0.94	1.08
Na_2O	3.58	4.61	4.94	3.42	3.74	3.29	6.11	6.03
K_2O	0.95	0.05	0.03	1.03	1.34	1.08	1.32	1.37
P_2O_5	0.28	0.23	0.21	0.23	0.31	0.40	0.07	0.07
MnO	0.130	0.216	0.199	0.107	0.142	0.144	0.016	0.020
H_2O+	0.30	4.13	2.70	0.75	0.64	0.91	0.42	1.25
H_2O^-	0.87	1.57	1.64	1.76	1.30	2.13	0.10	0.14
CO_2	0.09	0.09	0.06	0.07	0.05	0.08	0.07	0.04
Cr_2O_3	0.043	0.025	0.023	0.033	0.033	0.008	0.002	0.002
NiO	0.0190	0.0055	0.0050	0.0975	0.0065	0.0030	0.0035	0.0030

* Fe_2O_3 value corrected from Fe_TO_3 value using: corrected $Fe_2O_3=Fe_TO_3$ - FeO (1/.9).

Table 11. Carbon-carbonate data

Sample No.	% Total Carbon	% Inorg. Carbon (Avg.)	% Org. Carbon (Avg.)	Total Pyrol. Hydro. Yield (TPHC)%	Vol. Hydro. Carb. (VHC) ppm	Pyrol. HC Org. C. %	Temp. P ° C	VHC TPHC II
L5-78-BS								
2-1 (Sandy mudstone)	0.327	0.057	0.270					
2-2 (Volc. sandstone)			0.14	0.005	4.0	4.2	504	
2-3 (Mudstone)	0.293	0.078	0.215	0.02	25	4.6	480	0.13
2-4 (Diat. mudstone)	0.251	0.037	0.214					
2-5 (Diat. sandy siltstone)	0.702	0.049	0.653	0.027	67**	4.2	442	0.25
2-6 (Mudstone)	0.604	0.564	0.040					
2-9 (Clayey diatonite)	0.527	0.077	0.450					
2-10 (Not determined)	0.212	0.071	0.141					
2-11 (Diat. calc. mudstone)	7.030	6.678	0.352					
4-1 (Mudstone)	0.871	0.076	0.795	0.031	104**	3.9	461	0.34
4-2 (Volc. sandstone)			0.05	0.003	6.0	6.1	496	
4-5 (Mudstone)	0.807	0.042	0.765	0.035	96**	4.7	453	0.27
4-6 (Mudstone)	0.512	0.070	0.442					
4-7 (Siltstone)	0.842	0.066	0.776	0.01	17	9.0	484	
4-7			0.16					
5-1 (Diat. mudstone)	0.541	0.066	0.475					
5-3 (Mudstone)	0.293	0.070	0.223					
5-4 (Diat. mudstone)	0.202	0.057	0.145					

Table 11. (Continued)

Sample No.	% Total Carbon	% Inorg. Carbon (Avg.)	% Org. Carbon (Avg.)	Total Pyrol. Hydro. Yield (TPHC)%	Vol. Hydro Carb. (VHC) ppm	Pyrol. HC Org. C. %	Temp. P ° C	VHC TPHC II
L5-78-BS (Continued)								
5-5 (Volc. sandstone)	0.242	0.067	0.175	0.02	8	6.3	472	
5-5			0.27					
5-7 (Clayey limestone)	7.964	7.864	0.100					
5-10 (Andesite tuff)	0.185	0.065	0.120					
6-2 (Calc. volc. sandstone)	3.627	3.438	0.189					
6-3 (Sandy limestone)	7.030	6.921	0.109					
6-7 (Silty sandstone)	0.194	0.041	0.153					
7-3a (Mudstone)	0.856	0.051	0.805					
7-3b (Diat. mudstone)	0.412	0.051	0.361					
8-1 (Diat. mudstone)	0.417	0.093	0.324					
8-6 (Diat. mudstone)	0.248	0.049	0.199					
9-1 (Diat. mudstone)	0.457	0.043	0.414					
9-2 (Glauc. diat. mudstone)	3.210	0.075	3.135	0.078	193**	2.5	440	0.25
11-1	8.387	7.370	1.017	0.028	79**	2.8	452	0.28
11-2 (Clayey limestone)	8.924	7.865	1.059	0.027	63**	2.6	448	0.23
13-2	0.380	0.101	0.279					
13-9 (Pebbly sandstone)	0.351	0.108	0.24					

Table 11. (Continued)

Sample No.	% Total Carbon	% Inorg. Carbon (Avg.)	% Org. Carbon (Avg.)	Total Pyrol. Hydro. Yield (TPHC)%	Vol. Hydro. Carb. (VHC) ppm	Pyrol. HC Org. C. %	Temp. P ° C	VHC TPHC II
L5-78-BS (Continued)								
16-1 (Mudstone)	0.843	0.068	0.775	0.029	52**	3.8	456	0.18
16-3 (Tuff)	0.177	0.065	0.112					
16-4 (Volc. sandstone)		0.04	0.73	0.02	9	2.5	474	0.05
16-6 (Clayey limestone)	7.955	2.726	5.229	0.047	72**	0.9	452	0.15
16-7 (Tuff)		0.03	0.74	0.02	7	2.4	480	0.04
16-9 (Mudstone)	0.895	0.076	0.819	0.04	38	4.9	478	0.10
16-12 (Mudstone)	0.850	0.099	0.751					
19-2 (Diat. mudstone)	0.230	0.115	0.115					
21-1 (Volc. sandstone)	0.597	0.057	0.540	0.02	20	4.6	516	0.10
21-2 (Glauc. sandstone)			0.24	0.12	14	5.0	480	
22-4	0.765	0.062	0.703	0.059	403**	8.5	460	0.68
22-5 (Tuff limestone)	9.413	9.266	0.147					
22-7 (Clayey limestone)	7.899	7.066	0.833	0.012	18**	1.5	473	0.15
26-1 (Volc. sandstone)	0.355	0.142	0.213					
26-2 (Mudstone)	0.468	0.044	0.424	0.01	13	3.3	480	0.13
26-4 (Tuff)	6.939	6.031	0.908	0.028	171**	3.1	---	0.61
27-2 (Tuff)	0.086	0.067	0.019					
27-3 (Volc. sandstone)	0.076	0.061	0.015					

Table 11 (Continued)

Sample No.	% Total Carbon	% Inorg. Carbon (Avg.)	% Org. Carbon (Avg.)	Total Pyrol. Hydro. Yield (TPHC)%	Vol. Hydro. Carb. (VHC) ppm	Pyrol. HC Org. C. %	Temp. P °C	VHC TPHC II
L5-78-BS (Continued)								
27-5 (Volc. sandstone)	0.156	0.068	0.088					
27-6	0.606	0.051	0.555	0.02	11	4.6	502	0.06
28-1 (Diat. mudstone)	0.339	0.056	0.283					
28-3 (Diat. calc. sandstone)	5.887	4.943	0.944	0.031	104**	3.4	452	0.34
28-5 (Clayey limestone)	8.406	7.198	1.208	0.101	311**	8.4	444	0.31
70-B92								
3S3* (Brecciated mudstone)			0.41					
3S5* (Conglomerate)			0.25					
3S6 (Mudstone)	0.786	0.011	0.775					

*From Marlow and others (1976)
**Questionable value. May be contaminated from sample preparation.

Table 12. Bulk density data

	Wt. in grams	Displacement in c.c.	Density in g/cc	Lithology	Age
L5-78-BS					
2-2	208.40	88.5	2.35	vol.ss.	---
4-2	127.67	55.0	2.32	vol.ss.	(Barren)
5-5	143.87	49.9	2.88	vol.ss.	Late Jur.
5-10	24.05	13.5	1.78	andesite tuff	E. Mio. or Late Olig.
6-5	101.32	38.5	2.63	Vol. ss.	Late Plio. or Quat.
8-8	157.90	67.0	2.34	sandy siltst.	Quat.
13-2	163.22	70.0	2.33	micritic ls.	Late Plio.
13-3	9.75	3.7	2.63	sandstone	(Barren)
16-6	355.85	140.0	2.54	clayey ls.	(Barren)
21-2	243.40	101.0	2.41	sandstone	(Barren)
22-4	8.86	4.0	2.22	muddy ls.	Camp. or Maes. (No diatoms)
22-6	5.32	2.25	2.36	clayey ls.	Camp. or Maes. (No diatoms)
22-7	570.98	231.0	2.47	clayey ls.	Late Jur. (no diatoms)
22-18	217.18	93.0	2.34	calc. vol.ss.	---
27-1	362.76	190.0	1.91	sandy siltst.	Camp. or Maes. (No diatoms)
27-2	156.00	67.5	2.31	tuff	---
27-3	759.46	369.0	2.06	vol.ss.	
27-5	42.57	17.6	2.42	vol.ss.	
70-B92					
3S3*			2.05	brecciated mudstone	Paleoc. to Eoc.
3S5*			2.18	conglomerate	Paleoc. to Eoc.

*From Marlow and others, (1976)

Table 13. Grain size data

Sample No.	% Gravel	% Sand	% Silt	% Clay	Median (ϕ)	Mean (ϕ)	Sorting	Skewness	Kurtosis
L5-78-BS									
2-1 (Sandy mudstone)	--	14.03	64.80	21.17	6.42	6.47	2.50	0.153	1.247
2-3p (Mudstone w/clast)	1.83	0.05	60.70	37.42	7.24	7.56	2.82	0.225	0.959
2-8 (Glauc. diat. mudstone)	--	43.73	40.77	15.50	4.69	5.20	2.82	0.291	1.056
5-1 (Diat. mudstone)	--	15.84	48.78	35.39	6.77	7.15	3.10	0.231	0.814
5-10 (Andesite tuff)	--	38.02	40.96	21.01	4.52	5.44	2.92	0.507	0.885
6-7 (Silty sandstone)	--	82.00	16.12	1.88	3.16	3.34	1.55	0.262	2.641
7-3 (Diat. mudstone)	--	7.02	59.77	33.21	7.04	7.30	2.85	0.189	1.008
7-3a (Mudstone)	--	8.97	58.31	32.72	7.10	7.23	2.83	0.154	0.954
7-3b (Diat. mudstone)	--	7.05	78.06	14.89	6.40	6.25	2.03	0.064	1.410
16-3 (Tuff)	--	67.00	24.75	8.26	2.76	3.47	3.02	0.383	0.874
22-1 (Sandstone)	--	61.00	32.23	6.77	2.74	3.65	2.67	0.475	0.832
26-1 (Volc. sandstone)	--	70.00	21.38	8.62	3.02	3.87	2.60	0.515	1.180

Table 14. Porosity and permeability data

Sample No.	Lithology	Porosity (%)	Permeability (Millidarcy)	Age
L5-78-BS				
2-4	Diat. mudstone	68.3	5.46	Late Olig.
2-5	Diat. sandy mudstone	40.9	0.92	Olig. or early Mio.
2-8	Glauc. diat. mudst.	53.1	0.97	Late Olig.
2-11	Diat. calc. mudst.	45.1	1.25	Late Olig.
4-3	Mudstone	46.9	9.67	Early Olig.
5-3	Mudstone	22.0	1.49	Late Plio.
5-10	Andesite tuff	50.7	19.00	Late Olig. or e. Mio.
6-7	Silty sandstone	61.1	1.75	Late Olig. or e. Mio.
7-3	Diat. mudstone	57.4	1.67	Early mid. Mio.
9-2	Glauc. diat. mudst.	34.4	29.00	Latest mid. Mio.
16-12	Mudstone	57.0	0.77	Eocene(?)
22-2	Glauc. sandstone	70.6	8.43	Late. Cret. to Recent.
27-1	Sandy siltst./volc.ss.	55.9	3.61	Camp. or Maest.
28-1	Diat. mudstone	54.5	1.35	Late Miocene
70-B92				
3S3*	Brecc. mudstone	21		Paleo. or Eoc.
3S5*	Conglomerate	17		Paleo. or Eoc.

*From Marlow and others (1976)

Table 15. Age calls

Age Call Summary*

(D) = diatoms (Barron)
(F) = foraminifera (Arnal)
(Y) = pollen, spores, and/or dinoflagellates (Wingate)
(P) = pelecypods (Jones, Miller, or Marincovich)
(K) = potassium-argon date
(S) = silicoflagellates (Barron)
(R) = radiolarians (Kling)
(C) = coccoliths (Burky)

Sample No.	Age	
2-1	Late Oligocene	(D) (S)
2-3	Paleocene (?)	(F)
2-4	Late Oligocene	(D) (S)
2-5	Early Miocene	(D)
	Oligocene to early Miocene	(Y)
2-6	Earliest Miocene	(D)
	Oligocene to early Miocene	(Y)
2-8	Late Oligocene	(D) (S)
2-9	Late Oligocene	(D) (S)
2-11	Late Oligocene	(D) (S)
4-1	Early Oligocene (?)	(D)
	Oligocene to early Miocene (?)	(Y)
4-3	Early Oligocene (?)	(D)
4-5	Early Oligocene (?)	(D)
	Oligocene to early Miocene (?)	(Y)
4-6	Early Oligocene(?)	(D)
5-1	Latest Oligocene	(D)
5-2	Eocene	(Y)
5-3	Late Pliocene w/reworked Miocene	(D)
5-4	Late Oligocene	(D)
5-5	Late Jurassic (Kimmeridgian)	(P)
5-7	Late middle Miocene	(D)
5-10	Early Miocene or late Oligocene	(D)
6-3	Late Quaternary	(D)
6-5	Late Pliocene or Quaternary	(D)
6-7	Late Oligocene or early Miocene (?)	(D)
6-12	Late Oligocene	(D)
	Oligocene to early Miocene (?)	(Y)
7-3	Early middle Miocene	(D)
7-5	Middle middle Miocene	(D)

* See faunal lists and lithologies, p. 40 to p. 67.

Table 15. (continued)

Age Call Summary (Continued)

Sample No.	Age		
8-1	Latest Miocene	(D)	
	Pliocene (?)	(Y)	
8-6	Middle middle Miocene	(D)	
8-8	Quaternary	(D)	
9-1	Latest middle Miocene	(D)	(S)
9-2	Latest middle Miocene	(D)	
11-1	Middle middle Miocene	(D)	
13-1	Middle Pliocene	(D)	
13-2	Late Pliocene	(D)	
13-5	Middle Pliocene	(D)	
13-6	Late late Miocene to early Pliocene	(D)	
13-9	Late Pliocene	(D)	
15-3	Early Eocene (minimum)	(K)	
16-9	Late early or early middle Eocene	(C)	
	Eocene (?)	(F)	
16-12	Eocene (?)	(F)	
16-14	Late(?) Eocene	(F)	
19-2	Late Quaternary	(D)	
22-2	Late Cretaceous to Recent	(D)	
22-3	Middle Miocene	(D)	
22-4	Campanian or Maestrichtian	(Y)	
22-6	Campanian or Maestrichtian	(Y)	
22-7	Late Jurassic	(Y)	
25-4	Quaternary	(D)	
26-1	Early Pliocene	(D)	
26-6	Paleogene (probably Paleocene)	(Y)	
27-1	Campanian or Maestrichtian	(Y)	
	Cretaceous	(R)	
27-4	Paleogene (probably Paleocene)	(Y)	
28-1	Late Miocene	(D)	
28-2	Early Pliocene	(D)	
28-3	Latest Miocene or earliest Pliocene	(D)	
28-6	Early Quaternary	(D)	
	Late(?) Pliocene to Holocene	(P)	
BARTLETT addenda			
70-B92-3S3	Paleocene to Eocene	(Y)	
70-B92-3S5	Paleocene to Eocene	(Y)	
70-B92-3S6	Paleocene to Eocene	(Y)	

Table 16. Source of Age Calls

L5-78-BS 2-1 (sandy mudstone)

Diatom species include:

Asteromphalus symmetricus Schrader and Fenner
Cestodiscus muhinae Jouse
C. pulchellus Greville
Coscinodiscus tuberculatus var. *atlantica* Gleser and Jouse
Hemiaulus polycystinorum Ehrenberg
Melosira architecturalis Brun
Pseudotriceratium chenevieri (Meister) Gleser
P. aff. *chenevieri* (Meister) Gleser
Stictodiscus kittonianus Greville
Synedra miocenica Schrader
Thalassiosira cf. *irregulata* Schrader

Silicoflagellate species include:

Dictyocha deflandrei deflandrei Gleser
Distephanus crux darwinii Bukry
D. speculum (Ehrenberg) Haeckel (*cannopilean*)
Mesocena apiculata (Schulz) Hanna
Naviculopsis biapiculata (Lemmermann) Frenguelli

Age: Late Oligocene

L5-78-BS 2-3 (mudstone)

Foraminifera species include:

Ammodiscus cf. *incertus*
A. pennyi
Bathysiphon sp.
Hyperammina elongata
Rhabdammina eocenica

Age: Paleocene (?)

Table 16. (Continued)

L5-78-BS 2-4 (diatomaceous mudstone)

Diatom species include:

Asteromphalus symmetricus Schrader and Fenner
Cestodiscus muhinae Jouse
C. pulchellus Greville
Cymatosira compacta Schrader and Fenner
Hemiaulus polycystinorum Ehrenberg
Melosira architecturalis Brun
Pseudotriceratium chenevieri (Meister) Gleser
P. aff. *chenevieri* (Meister) Gleser
Stictodiscus kittonianus Greville
Synedra miocenica Schrader

Silicoflagellate species include:

Dictyocha deflandrei deflandrei Gleser
Distephanus speculum (Ehrenberg) Haeckel (*cannopilean*)
Mesocena apiculata (Schulz) Hanna
Naviculopsis biapiculata (Lemmermann) Frenguelli

Age: Late Oligocene

L5-78-BS 2-5 (diatomaceous sandy mudstone)

Diatom species include:

Actinocyclus ehrenbergii var. *tenella* (Brebisson) Hustedt
Cymatosira sp.
Coscinodiscus vigilans Schmidt
Hemiaulus polycystinorum Ehrenberg
Thalassiosira spinosa Schrader
T. spinosa var. *aspinosa* Schrader
T. fraga Schrader

Age: Early Miocene

Table 16. (Continued)

L5-78-BS 2-5 (Continued)

Pollen and spore species include:

Baculatisporites sp. cf. *Osmunda*
Caryapollenites sp.
Laevigatosporites sp.
Lycopodiumsporites sp.
Myricipites sp.
Nyssapollenites sp. 1
Pinaceae (bisaccates)
Pterocaryapollenites sp.
Stereisporites sp.
Taxodiaceaepollenites hiatus
Tricolporopollenites sp. 1 (microreticulate)
T. sp. cf. *Castanea*
Tsugaepollenites sp.
(Pollen comparable to the extant genera *Alnus*, *Betula*, and *Ulmus*.)

Age: Oligocene to early Miocene

L5-78-BS 2-6 (mudstone)

Diatom species include:

Actinocyclus ehrenbergii var. *tenella* (Brebisson) Hustedt
Cestodiscus pulchellus Greville
Cymatosira robustus Schrader and Fenner
Hemiaulus polycystinorum Ehrenberg
Rocella gelida (Mann) Bukry
Thalassiosira spinosa var. *aspinosa* Schrader

Age: Earliest Miocene

Table 16. (Continued)

L5-78-BS 2-6 (Continued)

Pollen and spore species include:

Baculatisporites sp. cf. *Osmunda*
Caryapollenites sp.
Ericipites sp.
Laevigatosporites sp.
Lycopodiumsporites sp.
Myricipites sp.
Nyssapollenites sp. 1 and 2
Pinaceae (bisaccates)
Pterocaryapollenites sp.
Stereisporites sp.
Taxodiaceaepollenites hiatus
Tricolporopollenites sp. 1 (microreticulate)
T. sp. cf. *Castanea*
Tsugaepollenites sp.
(Pollen comparable to the extant genera *Alnus*, *Betula*, *Juglans*, and *Ulmus*.)

Age: Oligocene to early Miocene

L5-78-BS 2-8 (glauconitic sandy mudstone)

Diatom species include:

Cestodiscus cf. *pulchellus* Greville
Goniothecium odontella Ehrenberg
Hemiaulus polycystinorum Ehrenberg
Hyalodiscus dentatus Korotkevicz
Pseudotriceratium chenevieri (Meister) Gleser
Synedra miocenica Schrader

Silicoflagellate species:

Dictyocha deflandrei deflandrei Gleser

Age: Late Oligocene

Table 16. (Continued)

L5-78-BS 2-9 (clayey diatomite)

Diatom species include:

Asteromphalus symmetricus Schrader and Fenner
Cestodiscus muhinae Jouse
C. pulchellus Greville
Hemiaulus polycystinorum Ehrenberg
Pseudotriceratium chenevieri (Meister) Gleser
P. aff. *chenevieri* (Meister) Gleser
Stictodiscus kittonianus Greville
Synedra miocenica Schrader
Thalassiosira cf. *irregulata* Schrader

Silicoflagellate species include:

Dictyocha deflandrei deflandrei Gleser
Distephanus crux darwinii Bukry
D. speculum (Ehrenberg) Haeckel (*cannopilean*)
Mesocena apiculata (Schulz) Hanna
Naviculopsis biapiculata (Lemmermann) Frenguelli

Age: Late Oligocene

L5-78-BS 2-11 (calcareous mudstone)

Diatom species include:

Cestodiscus muhinae Jouse
Hemianlus polycystinorum Ehrenberg
Pseudotriceratium chenevieri (Meister) Gleser
Stictodiscus kittonianus Greville
Synedra miocenica Schrader

Silicoflagellate species include:

Dictyocha deflandrei deflandrei Gleser
Mesocena apiculata (Schulz) Hanna

Age: Late Oligocene

Table 16. (Continued)

L5-78-BS 4-1 (mudstone)

Diatom species include:

Cocconeis sp. (w/a *raphe*)
Coscinodiscus oligocenicus Schrader and Fenner 1976
Pyrgupyxis sp.
Stephanopyxis grunowi Grove and Sturt
S. superba (Greville) Grunow
S. cf. *hyalomarginata* Hajos
S. cf. *oamaruensis* Hajos
Resting spores

Age: Early Oligocene (?)

Pollen and spore species include:

Caryapollenites sp.
Laevigatosporites sp.
Pinaceae (bisaccates)
Pterocaryapollenites sp.
Stereisporites sp.
Taxodiaceaepollenites hiatus
Tsugaepollenites sp.
(Pollen comparable to the extant genera *Alnus*, *Betula*, and *Ulmus*.)

Dinoflagellate cyst:

Deflandrea sp.
Dinoflagellate sp. 1

Age: Oligocene to early Miocene (?)

L5-78-BS 4-3 (mudstone)

Diatom species include: (same as 4-1)

Cocconeis sp. (w/a *raphe*)
Coscinodiscus oligocenicus Schrader and Fenner 1976
Pyrgupyxis sp.
Stephanopyxis grunowi Grove and Sturt
S. superba (Greville) Grunow
S. cf. *hyalomarginata* Hajos
S. cf. *oamaruensis* Hajos
Resting spores

Age: Early Oligocene (?)

Table 16. (Continued)

L5-78-BS 4-5 (mudstone)

Diatom species include:

Eunotia(?) sp. (freshwater)
Stephanopyxis grunowi Grove and Sturt
S. superba (Greville) Grunow
S. cf. *hyalomarginata* Hajos
S. cf. *oamaruensis* Hajos
Resting spores

Age: Early Oligocene (?)

Pollen and spore species include: (same as 4-1)

Caryapollenites sp.
Laevigatosporites sp.
Pinaceae (bisaccates)
Pterocaryapollenites sp.
Stereisporites sp.
Taxodiaceaepollenites hiatus
Tsugaepollenites sp.
(Pollen comparable to the extant genera *Alnus, Betula,* and *Ulmus.*)

Dinoflagellate cyst:

Deflandrea sp.
Dinoflagellate sp. 1

Age: Oligocene to early Miocene (?)

L5-78-BS 4-6 (mudstone)

Diatom species include:

Stephanopyxis oamaruensis Hajos
S. grunowi Grove and Sturt
S. hyalomarginata Hajos
S. superba (Greville) Grunow
Coscinodiscus radiatus Ehrenberg
Xanthiopyxis cf. *acrolopha* Forti
Coscinodiscus cf. *moelleri* var. *macroporus* Gran
Resting spores

Age: Early Oligocene (?)

Table 16. (Continued)

L5-78-BS 5-1 (diatomaceous mudstone)

Diatom species include:

Asteromphalus oligocenicus Schrader and Fenner
Cestodiscus muhinae Jouse
C. pulchellus Greville
Cymatosira compacta Schrader and Fenner
Hemiaulus polycystinorum Ehrenberg
Melosira architecturalis Brun
Pseudotriceratium chenevieri (Meister) Gleser
Rocella gelida (Mann) Bukry (common)
Synedra miocenica Schrader
Thalassiosira irregulata Schrader
T. spinosa var. *aspinosa* Schrader

Age: Latest Oligocene.

L5-78-BS 5-2 (volcanic sandstone)

(mostly non-marine)

Pollen and spore species include:

Caryapollenites verpites (Wilson and Webster) Nichols and Ott 1978
Engelhardtioidites sp.
Momipites coryloides Wodehouse emend. Nichols 1973
M. tenuipolus Anderson 1960
Pistillipollenites mcgregorii Rouse 1962
Platycaryapollentites sp.
Polyvestibulopollenites eocaenicus Krutzsch and Vanhoorne 1977
Thompsonipollis sp. cf. *T. crockettensis* Elisk 1974
Tiliaepollenites sp. cf. *Tilia crassipites* Wodehouse 1933
iliaepollenites sp. cf. *Intratriporopollenites microreticulatus* Mai 1961
Tiliaepollenites sp. cf. *Tilia vescipites* Wodehouse 1933
Tricolpites reticulatus Cookson 1947
Tricolporopollenites crucicingulum Krutzsch and Vanhoorne 1977
T. sp. cf. *T. kruschii* Elisk 1968
T. reticingulum Krutzsch and Vanhoorne 1977
(Pollen comparable to the extant genera *Alnus, Betula, Castanea, Ilex, Nyssa, Pterocarya, Liquidambar,* and *Salix,* occasional to common.)

Dinoflagellate cyst:

Wetzeliella articulata Eisenack 1938

Age: Eocene

Table 16. (Continued)

L5-78-BS 5-3 (mudstone)

Diatom species include:

Actinocyclus ehrenbergii Ralfs
Cymatosira sp. (reworked)
Synedra jouseana Sheshukova-Poretekaya (reworked)
Denticulopsis hustedtii (Simonsen and Kanaya) Simonsen (reworked)
Coscinodiscus temperei Brun (reworked)
C. plicatus Grunow (reworked)
Triceratium condecorum Ehrenberg (reworked)
Denticulopsis seminae var. *fossilis* (Schrader) Simonsen
Thalassiosira cf. *trifulta* Fryxell
T. gravida Cleve
Actinocyclus oculatus Jouse
Stephanopyxis horridus Koizumi

Age: Late Pliocene w/reworked Miocene

L5-78-BS 5-4 (mudstone)

Diatom species include:

Cestodiscus muhinae Jouse
C. pulchellus Greville
Coscinodiscus tuberculatus var. *atlantica* Gleser and Jouse
Cymatosira robusta Schrader and Fenner
Hemiaulus polycystinorum Ehrenberg
Melosira cf. *architecturalis* Brun
Pseudotriceratium chenevieri (Meister) Gleser
Sceptroneis tenue Schrader and Fenner
Synedra jouseana Sheshukova-Poretzkaya var. (*Thalassionema hirosakiensis* of Schrader and Fenner 1976)
Thalassiosira irregulata Schrader
Triceratium cruciforme Schimdt

Age: Late Oligocene

L5-78-BS 5-5 (volcanic sandstone) [Jones and Miller]

Pelecypod species:

Buchia rugosa Fischer

Age: Late Jurassic (Kimmeridgian)

Table 16. (continued)

L5-78-BS 5-7 (clayey limestone)

Diatom species include:

Actinocyclus ingens Rattray
Coscinodiscus plicatus Grunow
C. temperei Brun (old variety)
Denticulopsis antarctica (McCollum) Simonsen
D. hustedtii (Simonsen and Kanaya) Simonsen
D. lauta (Bailey) Simonsen
D. praedimorpha (Akiba) Barron
Mediaria splendia Sheshukova-Poretzkaya
Nitzschia heteropolica Schrader
Stepanopyxis schenckii Kanaya

Age: Late middle Miocene

L5-78-BS 5-10 (andesite tuff)

Diatom species include:

Cestodiscus cf. *muhinae* Jouse
C. pulchellus Greville
C. spp.
Coscinodiscus aff. *marginatus* of Schrader 1976
Cymatosira spp.
Stictodiscus kittonianus Greville

Age: Early Miocene or late Oligocene.

L5-78-BS 6-3 (sandy limestone)

Diatom species include:

Bacteriosira fragilis Gran
Denticulopsis seminae (Simonsen and Kanaya) Simonsen
D. seminae var. *fossilis* (Schrader) Simonsen
Thalassiosira excentrica var. *jouseae* (Kanaya) Koizumi
T. kyrophilia (Grunow) Joergensen
T. nidulus (Tempere and Brun) Jouse

Age: Late Quaternary

Table 16. (Continued)

L5-78-BS 6-5 (volcanic sandstone)

Diatom species include:

Bacteriosira fragilis Gran
Denticulopsis seminae var. *fossilis* (Schrader) Simonsen
Nitzschia sp.
Porosira glacialis (Grunow) Joergensen
Thalassiosira excentrica var. *jouseae* (Kanaya) Koizumi
T. gravida Cleve
T. hyalina (Grunow) Grunow

Age: Late Pliocene or Quaternary

L5-78-BS 6-7 (silty sandstone)

Diatom species include:

Cestodiscus muhinae Jouse
C. pulchellus Greville
Cymatosira compacta Schrader and Fenner
Melosira architecturalis Brun
Pseudotriceratium aff. *chenevieri* (Meister) Gleser
P. notabile Gleser
Stictodiscus kittonianus Greville
Thalassiosira spinosa var. *aspinosa* Schrader

Age: Latest Oligocene or early Miocene (?). (The above represent the oldest forms, only. The sample contains many burrows and it is likely that they result in Quaternary contamination

L5-78-BS 6-12 (diatomaceous siltstone)

Diatom species include:

Asteromphalus oligocenicus Schrader and Fenner
Cestodiscus muhinae Jouse
C. sp.
Coscinodiscus praenitidus Fenner
Cymatosira compacta Schrader and Fenner
Pseudotriceratium sp.

Table 16. (Continued)

Silicoflagellates:

Distephanus speculum (Ehrenberg) Haeckel (*cannopilean*)
Mesocena apiculata (Schultz) Hanna

Age: Late Oligocene

Pollen and spore species include:

Ericipites sp.
Laevigatosporites sp.
Pinaceae (bisaccates)
Pterocaryapollenites sp.
Taxodiaceaepollenites hiatus
Tsugaepollenites sp.
(Pollen comparable to the extant genera *Alnus*, *Betula*, *Ulmus*, and *Liquidambar(?)*.)

Age: Oligocene to early Miocene (?)

L5-78-BS 7-3 (diatomaceous mudstone)

Diatom species include:

Actinocyclus ingens Rattray
A. ingens var. *nodus* Baldauf
Denticulopsis lauta (Bailey) Simonsen
D. hyalina (Schrader) Simonsen
Mediaria splendida Sheshukova - Poretzkaya

Age: Early middle Miocene

L5-78-BS 7-5 (mudstone)

Diatom species include:

Actinocyclus ingens Rattray
Denticulopsis hustedtii (Simonsen and Kanaya) Simonsen
D. hyalina (Schrader) Simonsen
D. lauta (Bailey) Simonsen

Age: Middle middle Miocene

Table 16. (Continued)

L5-78-BS 8-1 (diatomaceous mudstone)

Diatom species include:

Actinocyclus ochotensis Jouse
Cosmiodiscus insignis Jouse
Coscinodiscus temperei Brun
Denticulopsis kamtschatica (Zabelina) Simonsen
D. cf. *kamchatica* (Zabelina) Simonsen
Thalassiosira gravida Cleve
T. jacksonii Koizumi and Barron
T. nativa Sheshukova - Poretzkaya
T. zabelinae Jouse

Age: Latest Miocene

Pollen and spore species include:

Compositae
Graminae
Laevigatosporites sp.
Onagraceae
Pinaceae (bisaccates)
Pterocaryapollenites sp.
Stereisporites sp.
Tricolporopollenites sp. 2 and 3
Tsugaepollenites sp.
(Pollen comparable to the extant genera *Alnus, Betula, Diervilla, Lonicera, Ulmus.*)

Age: Pliocene (?)

L5-78-BS 8-6 (diatomaceous mudstone)

Diatom species include:

Actinocyclus ingens Rattray
Coscinodiscus plicatus Grunow
Denticulopsis hustedtii (Simonsen and Kanaya) Simonsen
D. lauta (Bailey) Simonsen
Mediaria splendida Sheshukova - Poretzkaya
Stephanopyxis schenckii Kanaya

Age: Middle middle Miocene

Table 16. (Continued)

L5-78-BS 8-8 (sandy siltstone)

Diatom species include:

Bacteriosira fragilis Gran
Nitzchia sp.
Rhizosolenia hebetata f. *hiemalis* Gran
Thalassiosira gravida Cleve
T. hyalina (Grunow) Grunow

Age: Quaternary

L5-78-BS 9-1 (diatomaceous mudstone)

Diatom species include:

Coscinodiscus plicatus Grunow
C. yabei Kanaya
Denticulopsis hustedtii (Simonsen and Kanaya) Simonsen
D. lauta Bailey
Nitzschia cf. *heteropolica* Schrader
Rhizoselenia barboi Brun

Silicoflagellate species include:

Distephanus pseudofibula (Schulz) Bukry
Mesocena hexagona Haekel

Age: Latest middle Miocene

L5-78-BS 9-2 (glauconitic diatomaceous mudstone)

Assemblage identical to 9-1.

Age: Latest middle Miocene

Table 16. (Continued)

L5-78-BS 11-1 (clayey limestone)

Diatom species include:

Actinocyclus ingens Rattray
Coscinodiscus praeyabei Schrader
C. aff. *plicatus* Grunow
Denticulopsis hustedtii (Simonsen and Kanaya) Simonsen (very rare)
D. hyalina (Schrader) Simonsen
D. lauta (Bailey) Simonsen
Stephanopyxis schenckii Kanaya

Age: Middle middle Miocene

L5-78-BS 13-1 (sandstone)

Diatom species include:

Denticulopsis kamtschatica (Zabelina) Simonsen
D. seminae var. *fossilis* (Schrader) Simonsen
Stephanopyxis horridus Koizumi
Thalassiosira zabelinae Jouse

Age: Middle Pliocene

L5-78-BS 13-2 (muddy sandstone)

Diatom species include:

Bacteriosira fragilis Gran
Denticulopsis kamtschatica (Zabelina) Simonsen
D. seminae var. *fossilis* (Schrader) Simonsen
Stephanopyxis horridus Koizumi
Thalassiosira antiqua (Grunow) Cleve
T. gravida Cleve
T. gravida var. 1 (Leg 57)
T. hyalina (Grunow) Grunow
T. nidulus (Tempere and Brun) Jouse
T. nordenskioldii Cleve
T. oestrupii (Ostenfeld) Proshkina - Lavrenko

Age: Late Pliocene

Table 16, (Continued)

L5-78-BS 13-5 (pebbly sandstone)

Diatom species include:

Denticulopsis kamtschatica (Zabelina) Simonsen
D. seminae var. *fossilis* (Schrader) Simonsen
Thalassiosira antiqua Grunow - Cleve
T. nidulus var. *delicata* Barron
T. zabelinae Jouse

Age: Middle Pliocene

L5-78-BS 13-6 (pebbly sandstone)

Diatom species include:

Coscinodiscus pustulatus Mann
Thalassiosira gravida Cleve (flat form)

Age: Late late Miocene to early Pliocene

L5-78-BS 13-9 (pebbly sandstone)

Assemblage virtually identical to 13-2

Age: Late Pliocene

L5-78-BS 15-3 (basalt)

Potassium-Argon age report (whole rock):

K_2O = 2.189, 2.191%
$^{40}Ar(rad)/gm = 1.752 \times 10^{-10}$ moles/gm
$^{40}Ar(rad)/^{40}Ar(total) = 84.53$

Age: 54.7 million years ±1.08 m.y. (15-3 shows signs of having been altered - hence the age represents a minimum value.)

Table 16 (Continued)

L5-78-BS 16-9 (mudstone) [Bukry]

Coccolith or nannoplankton species include:

Chiasmolithus sp. aff. *C. expansus* Bramlette and Sullivan
C. solitus Bramlette and Sullivan
Coccolithus pelagicus Wallich
C. sp. cf. *C. pelagicus* Wallich (small, high relief)
Cyclicargolithus pseudogammation Bouche
Discolithina pectinata Bramlette and Sullivan
D. sp. cf. *D. plana* Bramlette and Sullivan
Koczyia wechesensis Bukry and Percival
Reticulofenestra sp. aff. *R. dictyoda* Deflandre
R. samodurovi Hay, Mohler, and Wade
Syracosphaera fimbriata Bramlette and Sullivan
Transversopontis pulcher Deflandre

Age: Late early or early middle Eocene

Foraminifera species include:

Bathysiphon eocenica
B. cf. *eocenica*
Haplophragmoides sp.
Robulus sp. (pyritized)

Age: Eocene (?)

L5-78-BS 16-12 (mudstone)

Foraminifera species include:

Bathysiphon antipodum
B. cf. *eocenica*
Epistomina partschiana

Age: Eocene (?)

Table 16. (Continued)

L5-78-BS 16-14 (mudstone)

Foraminifera species include:

Bathysiphon eocenica
Bifarina nuttali
Cibicides pachyderma
Dentalina kreyenhagenensis
Globobulimina pacifica
Hoglundina eocenica
Rhabdammina sp. (pyritized)
Rodulus alato-limbatus
R. arcuato-striatus

Age: Late(?) Eocene

L5-78-BS 19-2 (diatomaceous mudstone)

Diatom species include:

Actinocyclus divisus (Grunow) Hustedt
A. ochotensis Jouse
Bacteriosira fragilis Gran
Denticulopsis seminae (Simonsen and Kanaya) Simonsen
D. seminae var. *fossilis* (Schrader) Simonsen
Rhizosolenia curvirostris Jouse
R. hebetata f. *hiemalis* Gran
Thalassiosira gravida Cleve
T. nidulus (Tempere and Brun) Jouse
T. pacifica Gran and Angst

Age: Late Quaternary

L5-78-BS 22-2 (glauconitic sandstone)

Diatom species include:

Coscinodiscus fragments
Melosira sulcata (Ehrenberg) Kutzing
Radiolarian fragments

Age: Late Cretaceous to Recent

Table 16. (Continued)

L5-78-BS 22-3 (pebbly sandstone)

Diatom species include:

Actinocyclus ingens Rattray
Coscinodiscus praeyabei (Schrader) Simonsen
Denticulopsis hyalina (Schrader) Simonsen
D. lauta (Bailey) Simonsen
Goniothecium tenue Brun
Stephanopyxis schenckii Kanaya

Quaternary contaminants:

Denticulopsis seminae Simonsen and Kanaya (one specimen)
Rhizosolenia hebetata f. *hiemalis* Gran (one specimen)

Age: Middle Miocene

L5-78-BS 22-4 (laminated sandstone and siltstone)

Diatom species include:

Coscinodiscus marginatus Ehrenberg
C. radiatus Ehrenberg
Rhizosolenia barboi Brun
Thalassiosira antiqua (Grunow) Cleve
Thalassiothrix longissima Cleve and Grunow

Age: Late Miocene or Quaternary

Pollen and spore species include:

Aquilapollenites reticulatus (Mtchedlishvili) Tschudy and Leopold, 1971
A. striatus Funkhouser 1961
A. sp.
Azonia sp. cf. *A. ovata* (Chlonova) Felix and Burbridge 1973
A. sp. cf. *A. recta* (Bolkhovitina) Samoilovich 1961
Fibulapollis mirificus (Chlonova) Chlonova 1961
Tricolporate sp. (indeterminate)
Triporate sp. (indeterminate)
cf. *Umbosporites callosus* Newman 1965

Table 16. (Continued)

Dinoflagellate cysts:

Adnatosphaeridium filiferum (Cookson and Eisenack) Williams and Downie in Davey et al. 1969
Chatangiella granulifera (Manum) Lentin and Williams 1976
Chatangiella sp.
Chlamydophorella nyei Cookson and Eisenack 1958
Cyclonephelium sp. cf. *C. distinctum* Deflandre and Cookson 1955
Microdinium irregulare Clarke and Verdier 1967
Odontochitina operculata (O. Wetzel) Deflandre and Cookson 1955
Oligosphaeridium sp. cf. *O. pulcherrimum* (Deflandre and Cookson) Davey and Williams in Davey et al. 1967
Eurydinium sp.
Oligosphaeridium sp.
Spinidinium sp.
Spiniferites sp.

Age: Campanian or Maestrichtian

L5-78-BS 22-6 (clayey limestone)

Pollen and spore species include:

Aquilapollenites pyriformis Norton 1965
Aquilapollenites senonicus (Mtchedlishvili) Tschudy and Leopold 1971
Aquilapollenites striatus Funkhouser 1961
Aquilapollenites tripodiformis Tschudy and Leopold 1971
Cercidiphyllites brevicolpatus Mtchedlishvili 1961
Cranwellia striata (Couper) Srivastava 1967
Fibulapollis mirificus (Chlonova) Chlonova 1961
Radialisporis radiatus (Krutzsch) Krutzsch 1967
Wodehouseia stanleyi Srivastava 1966
Wodehouseia sp.

Table 16. (Continued)

Dinoflagellate cysts:

Alterbia acutula (Wilson) Lentin and Williams 1973
Deflandrea diebelii Alberti 1959
Fromea chytra (Drugg) Stover and Evitt 1978
Glyphanodinium facetum Drugg 1964
Laciniadinium firmum (Harland) Morgan 1977
Spiniferites sp. cf. *S. granulatus* (Davey) Lentin and Williams 1973

Age: Campanian or Maestrichtian

L5-78-BS 22-7 (clayey limestone)

Dinoflagellate cysts:

Bourkidinium granulatum Morgan 1975
Chytroeisphaeridia chytroeides (Sarjeant) Downie and Sarjeant 1965
Cyclonephelium distinctum Deflandre and Cookson 1955
Gardodinium trabeculosum (Gocht) Alberti 1961
Gonyaulacysta jurassica (Deflandre) Norris and Sarjeant 1965
G. jurassica subsp. *longicornis* (Deflandre) Lentin and Williams 1973
Lithodinia pocockii (Sarjeant) Davey 1979
Omatia alaskaensis Stover and Evitt 1978
Sirmiodinium grossi Alberti 1961
Tubotuberella sp. cf. *"Psaligonyaulax apatela"* auct. non (Cookson and Eisenack) Sarjeant 1969 in Brideaux 1976
Batiacasphaera sp.
Fromea sp.
Hystrichogonyaulax sp.
Kallosphaeridium sp.
Lanterna sp.
Leptodinium sp.
Meiourogonyaulax sp.
Oligosphaeridium sp.
Palaeoperidinium sp.
Sentusidinium sp.

Table 16. (Continued)

Questionable identifications, dinoflagellate cysts:

Carpathodinium predae (Beju) Drugg 1978
Clathroctenocystis elegans Wiggins 1972
Cometodinium whitei (Deflandre and Courteville) Stover and Evitt, 1978
Gonyaulacysta perforobtusa Duxbury 1977
Leptodinium subtile Klement 1960
Scriniodinium sp. cf. *S. crystallinum* (Deflandre) Klement, 1960
Belodinium sp.
Carpathodinium sp.
Odontochitina sp.

Age: Late Jurassic

L5-78-BS 25-4 (coarse-grained sandstone)

Diatom species include:

Bacteriosira fragilis Gran
Denticulopsis seminae (Simonsen and Kanaya) Simonsen
D. seminae var. *fossilis* (Schrader) Simonsen
Porosira glacialis (Grunow) Joergensen
Rhizosolenia hebetata f. *hiemalis* Gran
Thalassiosira gravida Cleve
T. oestrupii (Ostenfeld) Proshkina - Lavrenko

Age: Quaternary

L5-78-BS 26-1 (volcanic sandstone)

Diatom species include:

Cosmiodiscus insignis Jouse
Denticulopsis kamtschatica (Zabelina) Simonsen
Thalassiosira oestrupii (Ostenfeld) Proshkina - Lavrenko
T. zabelinae Jouse

Silicoflagellate species include:

Distephanus boliviensis jimlingii Bukry

Age: Early Pliocene

Table 16. (Continued)

L5-78-BS 26-6 (clayey limestone)

Pollen and spore species include:

Caryapollenites sp.
cf. Rosaceae
Paraalnipollenites confusus (Zaklinskaya) Hills and Wallace, 1969
cf. *Ulmus*
Pesavis tagluensis Elsik and Jansonius, 1974

Dinoflagellate cysts include:

Deflandrea phosphoritica Eisenack, 1938
Impagidinium sp. cf. *I. maculatum* (Cookson and Eisenack) Stover and Evitt
Impagidinium sp. (?)
Kallosphaeridum sp.
Paleotetradinium minusculum (Alberti) Stover and Evitt, 1978

A Late Cretaceous pollen grain, *Aquilapollenites reticulatus*, was observed, but considered recycled.

Age: Paleogene (probably Paleocene)

L5-78-BS 27-1 (sandy siltstone interbedded with volcanic sandstone)

Pollen and spore species include:

Aquilapollenites parallelus Tschudy 1969
Aquilapollenites sp. cf. *A. senonicus* (Mtchedlishvili) Tschudy and Leopold 1971
Cupanieidites sp.
Erdtmanipollis pachysandroides Krutzsch 1962
Fibulapollis mirificus (Chlonova) Chlonova 1961
Kurtzipites trispissatus Anderson 1960
Tricolpites sp. 11 McIntyre 1974
Tricolporate sp. (undifferentiated - rare to common)
Triporate sp. (undifferentiated - rare to common)
Wodehouseia stanleyi Srivastava 1966

Table 16. (Continued)

Dinoflagellate cysts:

Adnatosphaeridium filiferum (Cookson and Eisenack) Williams and Downey in Davey et al. 1969
Chatangiella sp. cf. *C. ditissima* (McIntyre) Lentin and Williams 1976
Deflandrea diebelii Alberti 1959
Elytrocysta druggii Stover and Evitt 1978
Isabelidinium cooksoniae (Alberti) Lentin and Williams 1977
Microdinium ornatum Cookson and Eisenack 1960
Senegalinium obscurum (Drugg) Stover and Evitt 1978
Spiniferites sp. cf. *S. granulatus* (Davey) Lentin and Williams 1973

Age: Campanian or Maestrichtian

Radiolarian species (poorly preserved): [Kling]

Dictyomitra (s.l.) sp.
Phaseliforma(?) sp.
Pseudodictyomitra(?) sp.

Age: Cretaceous

L5-78-BS 27-4 (volcanic sandstone)

Pollen and spore species include:

Caryapollenites sp.
Paraalnipollenites confusus (Zaklinskaya) Hills and Wallace, 1969
Pesavis tagluensis Elsik and Jansonius, 1974
cf. *Momipites* sp.

Table 16. (Continued)

Dinoflagellate cysts include:

Alisocysta sp. cf. *A. circumtabulata* (Drugg) Stover and Evitt, 1978
Areoligera volata Drugg, 1967
Cannosphaeropsis franciscana Damassa, 1979
Deflandrea phosphoritica Eisenack, 1938
Eocladopyxis peniculata Morgenroth, 1966
Fromea laevigata (Drugg) Stover and Evitt, 1978
Kallosphaeridium sp.
Microdinium ornatum Cookson and Eisenack, 1960
Senegalinium obscurum (Drugg) Stover and Evitt, 1978
Tanyosphaeridium xanthiopyxides (Wetzel) Stover and Evitt, 1978
Turbiosphaera filosa (Wilson) Anchangelsky, 1969
cf. *Elytrocysta druggii* Stover and Evitt, 1978

Recycled Cretaceous fossils:

Aquilapollenites striatus Funkhouser, 1969
Aquilapollenites sp. cf. *A. delicatus* Stanley, 1961
Chatangiella victoriensis (Cookson and Manum) Lentin and Williams, 1976
Odontochitina operculata (Wetzel) Deflandre and Cookson, 1955

Age: Paleogene (probably Paleocene)

L5-78-BS 28-1 (diatomaceous mudstone)

Diatom species include:

Cosmiodiscus insignis Jouse
Coscinodiscus temperei Brun
Denticulopsis cf. *kamtschatica* (Zabelina) Simonsen
Thalassiosira antiqua (Grunow) Cleve
T. nativa Sheshukova - Poretskaya
T. zabelinae Jouse
T. aff. *zabelinae* Jouse

Age: Late Miocene

Table 16. (Continued)

L5-78-BS 28-2 (diatomaceous mudstone)

Diatom species include:

Actinocyclus ochotensis Jouse
Cosmiodiscus insignis Jouse (common)
Coscinodiscus pustulatus Mann
Denticulopsis hustedtii (Simonsen and Kanaya) Simonsen
D. kamtschatica Zabelina
Thalassiosira gravida Cleve
T. gravida Cleve (flat form)
T. jacksonii Koizumi and Barron
T. nativa Sheshukova-Poretzkaya (of Koizumi, 1975)
T. nidulus var. *delicata* Barron
T. oestrupii (Ostenfeld) Proshkina - Lavrenko
T. aff. *oestrupii* (Leg 57 sp.)
T. *punctata* Jouse
T. *zabelinae* Jouse

Age: Early Pliocene

Table 16. (Continued)

L5-78-BS 28-3 (diatomaceous calcareous sandstone)

Diatom species include:

Cosmiodiscus insignis Jouse
Denticulopsis hustedtii (Simonsen and Kanaya) Simonsen
D. kamtschatica (Zabelina) Simonsen (rare)
D. cf. *kamtschatica* (Zabelina) Simonsen
Thalassiosira antiqua (Grunow) Cleve
T. gravida var. 1 (Leg 57)
T. hyalinopsis Barron
T. nidulus var. *delicata* Barron
T. punctata Jouse
T. zabelinae Jouse

Age: Latest Miocene or earliest Pliocene

L5-78-BS 28-6 (clayey limestone)

Diatom species include:

Actinocyclus oculatus Jouse
Denticulopsis seminae (Simonsen and Kanaya) Simonsen
D. seminae var. *fossilis* (Schrader) Simonsen
Porosira glacialis (Grunow) Joergensen
Rhizosolenia curvirostris Jouse
Thalassiosira gravida Cleve
T. gravida Cleve (flat form)
T. nidulus (Tempere and Brun) Jouse

Age: Early Quaternary

Pelecypod species: [Marincovich]

Nuculana fragments
Serripes groenlandicus Brugiere (1 valve)

Age: Late(?) Pliocene to Holocene

Addendum from dredge samples from the 1970 cruise of the USNS BARTLETT in the Bering Sea.

Table 16. (Continued)

70-B92-3S3 (brecciated mudstone)

Pollen and spore species include:

Caryapollenites sp. cf. *C. veripites* (Wilson and Webster) Nichols and Ott, 1978
Caryapollenites sp.
Paraalnipollenites confusus (Zaklinskaya) Hills and Wallace, 1969
Pesavis tagluensis Elsik and Jansonius, 1974
cf. *Alnus*
cf. *Castanea*
cf. Tiliaceae

Dinoflagellates include:

Apectodinium homomorphum (Deflandre and Cookson) Lentin and Williams, 1977
Kallosphaeridium sp.

Recycled Cretaceous pollen grain:

Aquilapollenites scabridus B. Tschudy, 1969

Age: Paleocene to Eocene

70-B92-3S5 (granule conglomerate)

Pollen and spore species include:

Caryapollenites sp.
Paraalnipollenites confusus (Zaklinskaya) Hills and Wallace, 1969
Pesavis tagluensis Elsik and Jansonius, 1974
cf. *Alnus*
cf. *Betula*

Dinoflagellate cysts include:

Kallosphaeridium sp.
Nematosphaeropsis sp. cf. *N. philippotii* (Deflandre) DeConinck, 1969
Senegalinium obscurum (Drugg) Stover and Evitt, 1978

Age: Paleocene to Eocene

Table 16. (Continued)

70-B92-3S6 (mudstone)

Pollen and spore species include:

Caryapollenites veripites (Wilson and Webster) Nichols and Ott, 1978
Caryapollenites sp.
Microthyriaceae fruiting bodies
Paraalnipollenites confusus (Zaklinskaya) Hills and Wallace, 1969
Pesavis tagluensis Elsik and Jansonius, 1974
cf. Betulaceae
cf. *Castanea*
cf. Tiliaceae
cf. *Ulmus*

Dinoflagellates include:

Batiacasphaera sp.
Spiniferites sp.

Age: Paleocene to Eocene