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27. CLAY MINERALOGY OF SEDIMENTS FROM THE GALICIA MARGIN, ODP LEG 103[1]

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ABSTRACT

Samples from Cenozoic and Mesozoic sediments drilled during ODP Leg 103 were analyzed for clay mineralogy. Kaolinite, chlorite, illite, and smectite occur in most of the samples studied; palygorskite and sepiolite occur principally in Paleogene and Eocene brown clays. In general, throughout the section deposited in the syn- and post-rift period, the more calcareous-rich pelagic sediments contain greater amounts of smectite and lesser amounts of kaolinite and chlorite than do the calcareous-poor terrigenous sediments. The clay data presented here also lend support to the general paleoenvironmental interpretation of a relatively warm climate throughout the Cretaceous and early Tertiary and a relatively cooler climate from the Oligocene to the present day.

INTRODUCTION

The Galicia margin, northwest of the Iberian Peninsula, is a sediment-starved passive continental margin (Montadert et al., 1974, 1979a; Groupe Galice, 1979; Boillot et al., 1979, 1980). Tilted rift blocks, trending north and dipping gently east, form a series of half-grabens. On the western, uplifted side of some of these blocks, basement and possibly pre-rift sedimentary rocks crop out, making this an ideal margin to investigate the basement and oldest sedimentary strata by Ocean Drilling Program (ODP) drilling. Principal objectives of coring and logging during Leg 103 included studying the history of rifting, subsidence, and sedimentation on this margin and the relation of these processes to the initiation and progressive opening of the adjacent North Atlantic. These results would complement earlier drilling on the Iberian margin at Site 398, drilled during Deep Sea Drilling Project (DSDP) Leg 47B (Sibuet, Ryan, et al., 1979).

Five sites were drilled during Leg 103 (Fig. 1). Sites 638, 639, and 641 extended the results of Leg 47B by coring through the syn- and pre-rift strata, possibly to the top of basement near the western edge of the margin. Site 637, located at the western edge of the margin close to the boundary between oceanic and continental crust, recovered presumed upper mantle peridotite. Drilling at Site 640 was on the summit of the ridge closest to the oceanic/continental crust transition, over the deep S reflector widely believed to represent the ductile/brittle boundary within continental crust (Montadert et al., 1979b). Preliminary results from these drill sites are reported in the Leg 103 *Initial Report* (Boillot, Winterer, et al., 1987); more detailed results from shore-based studies following the cruise are given in the various specialty chapters published in this volume.

The cores recovered at these five sites include a great variety of sedimentary rock types, in addition to a suite of volcanic and metamorphic rocks. The purpose of this study was to document the clay mineralogy of the recovered sediments, particularly in the Cenozoic sections of the drill sites. Results presented in this paper, together with results presented in the Leg 103 site chapters (Boillot, Winterer, et al., 1987), in other specialty chapters in this volume, and in the Leg 47B volume (Sibuet, Ryan, et al., 1979), document temporal and areal changes in sediment sources and modes of sediment deposition on the Galicia margin.

METHODS

X-ray diffraction (XRD) analyses were made on sediments from all five sites drilled during ODP Leg 103. In general, one or two samples were analyzed from every core, except where core recovery was poor. Attempts were made to sample representative sediment types from each core; where sediment types showed considerable variation, more closely spaced samples were taken.

Samples were prepared and analyzed according to the procedure outlined by Hein et al. (1976). X-ray patterns were run on a Philips ADP 3520 X-ray diffractometer with nickel-filtered Cu-K_α radiation and machine settings of 40 kV and 35 mA. Unglycolated profiles were run from 2°–15° 2θ; glycolated profiles were run from 2°–15° 2θ and 24°–26° 2θ. Clay minerals were identified by their characteristic basal XRD maxima, or "peaks." Semiquantitative clay percentages were determined on the glycolated X-ray analog records by the peak area method (Milliman and Bornhold, 1973), multiplied by Biscaye's (1965) weighting factors, and normalized to 100% (Tables 1 and 2). Kaolinite and chlorite are reported together where their percentages could not be differentiated on the 24°–26° 2θ glycolated profile.

Table 1 lists both unweighted and weighted peak areas, for ease in later recalculation of the data to compare with other clay mineralogical results generated with different weighting factors. The total area under the sum of the clay peak areas serves as an estimate of the quality of the percentages determined. Percentages were not calculated for profiles with poorly defined peaks or very small peak areas; these samples are omitted from Table 1. Reproducibility of results is ±5%.

RESULTS

General Comments

The clay component of sediments recovered during Leg 103 contains kaolinite, chlorite, illite, and smectite, in varying proportions. In a few samples, palygorskite and sepiolite are also present. Characteristic peaks and correction factors are given in Table 2. Semiquantitative percentages of the minerals are plotted vs. depth below seafloor in Figures 2 through 7. The principal downhole trends in clay mineralogy at each Leg 103 site are discussed below, in site-chronologic order.

Site 637

Drilling at Site 637 was on the eastern flank of a buried ridge of serpentinized, foliated peridotite (Fig. 1). This peridotite is buried beneath a 212-m-thick section of sediments, divided into three lithologic units that are described both in the "Site 637" chapter (Boillot, Winterer, et al., 1987) and in Comas and Maldonado (this volume). Figure 2 shows the downhole trends in clay mineralogy at this site.

[1] Boillot, G., Winterer, E. L., et al., 1988. *Proc. ODP, Sci. Results*, 103: College Station, TX (Ocean Drilling Program).

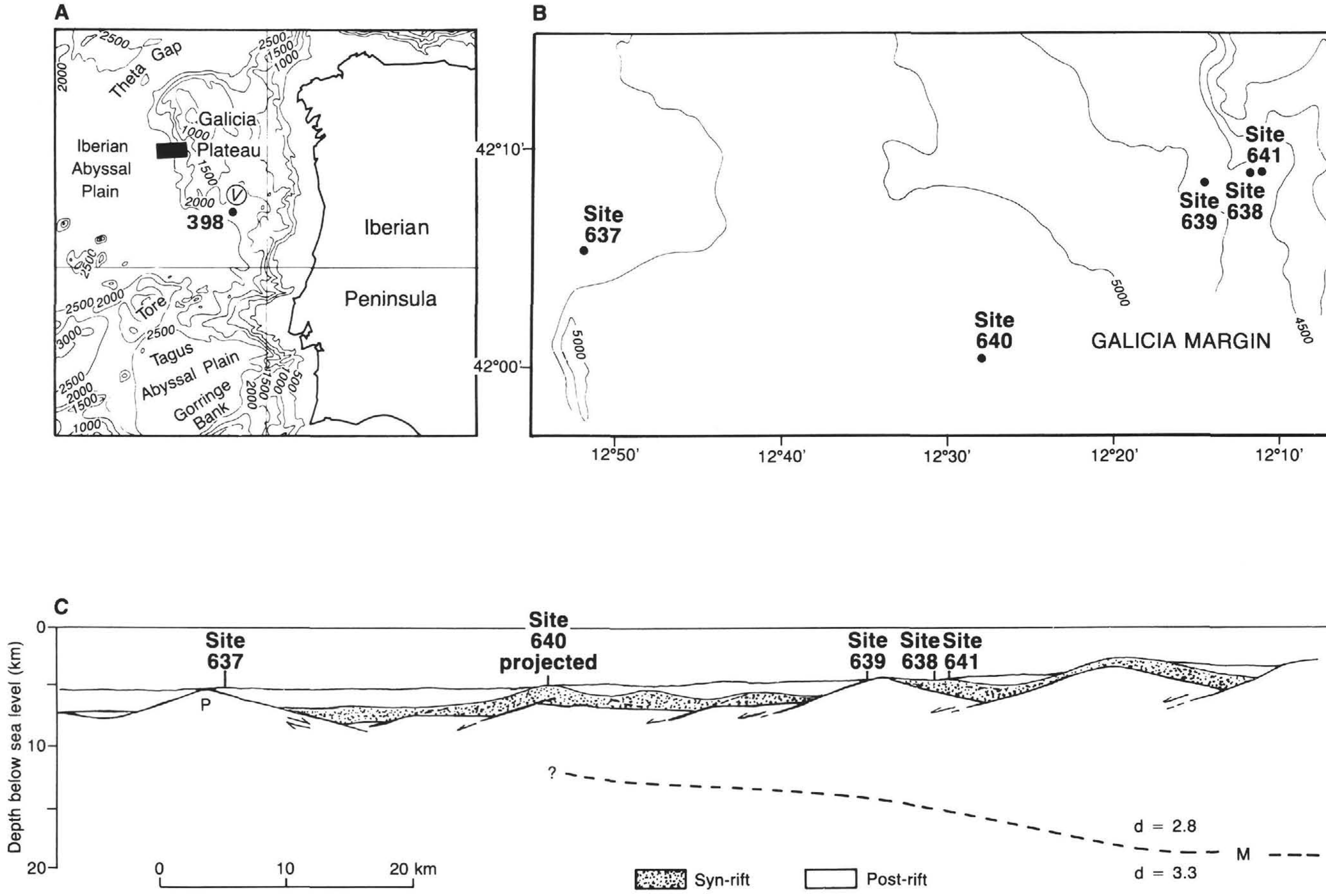

Figure 1. **A.** Location map of Galicia margin region northwest of Iberian Peninsula. Bathymetric contours in meters. Box indicates area of ODP Leg 103 drilling. Black dot shows location of Site 398 drilled during DSDP Leg 47B south of Vigo Seamount (V). **B.** Bathymetric map showing location of sites drilled during Leg 103. Modified from Sea Beam map. Contour interval, 250 m. Location of map shown in Figure 1A. **C.** Schematic cross section across Galicia margin drawn from seismic data and drilling results. P = peridotite ridge. Low-angle listric faults beneath half-grabens are hypothetical.

Lithologic Unit I (0–135 m below seafloor [mbsf]) consists of upper Pliocene to upper Pleistocene turbidites, interbedded with nannofossil marl. The turbidites average about 25 cm in thickness. They consist of a graded, gray silt layer, structureless or with parallel laminae, that passes upward into an olive-gray clay. A light gray nannofossil marl commonly overlies the silt-clay couplet and is typically homogenous. The origin of the nannofossil marl layers is not entirely clear, though some show evidence of redeposition (i.e., little dissolution of nannofossils though the water depth of the site is near the carbonate compensation depth (CCD), presence of a small percentage of reworked older species, etc.; see "Site 637" chapter; Boillot, Winterer, et al., 1987). The silt layers become thinner and less abundant downsection.

No clay mineralogy samples were taken from Cores 103-637A-1R through 103-637A-5R because of little or no core recovery. Approximately two to three samples were taken from each of the remaining cores in lithologic Unit I (Cores 103-637A-6R through 103-637A-15R), representing the silt and clay turbidite couplets as well as the nannofossil marl. The clay component in these sediments averages about 20% kaolinite, 15% chlorite, 50% illite, and 15% smectite. The abundance of smectite has the widest range (from 0% to 29%) and is related to the carbonate content: the nannofossil marls typically have more smectite than the clay and silty clay turbidites. The large fluctuations in the clay profile reflect the overall heterogeneity of the sediment types included in this unit.

Lithologic Unit II (135–185 mbsf) consists of upper Miocene to middle Pliocene brown clay and nannofossil marl and includes some distinct slumped intervals. These sediments were interpreted aboard ship as being pelagic sediment and weathering products from the underlying basement, slumped off the basement hill (see "Site 637" chapter; Boillot, Winterer, et al., 1987).

Most of the samples taken from lithologic Unit II consist of nannofossil marl. The clay mineralogy of these marls is similar to that of the marls sampled from lithologic Unit I, averaging 20% kaolinite, 15% chlorite, 40% illite, and 25% smectite. The silt and clay turbidite layer that was closely sampled in Core 103-637A-17R shows the same increase in amount of smectite upsection (i.e., toward the capping marl) as seen in similar layers in lithologic Unit I.

Lithologic Unit III (185–212 mbsf) consists of reddish brown and grayish brown clay with some exotic lumps of light-colored clay. The brown clays include zeolites, glass, iron oxide particles, and a small percentage of silt-sized terrigenous material (see "Site 637" chapter; Boillot, Winterer, et al., 1987). Based on ichthyoliths, this unit is of Paleogene-Eocene age (Doyle, this volume; Moullade et al., this volume). It was interpreted aboard ship as being a mixture of slowly accumulating pelagic clay, weathering products from the underlying basement, and continental detritus brought to the site by dilute nepheloid or turbidity currents.

The clay mineralogy of the reddish brown and grayish brown clays of lithologic Unit III is distinctly different than that of the overlying units. Only very small amounts of kaolinite and chlorite (2%–5%) and smectite (7%–13%) are present. Illite typically comprises 12%–13% of the clay component, though the uppermost sample contains 36%. The bulk of the clay component consists of palygorskite (29%–46%) and sepiolite (36%–48%). The significance of this distinctive clay assemblage is discussed in the following text.

Site 638

Site 638 is on a rift block close to the western edge of the Galicia margin (Fig. 1). Together with Site 639, these sites were drilled to yield data on the very early history of the margin, on the timing of rifting, and on the timing of paleoenvironmental changes in this region of the North Atlantic. A total of 547.2 m was penetrated in Holes 638B and 638C at this site, recovering post- and syn-rift sediments that are divided into three lithologic units. Clay mineral analyses were run on samples from each of these units; the data are presented in Table 1 and graphed in Figure 3.

Lithologic Unit I (0–183.6 mbsf), recovered only in Hole 638B, consists primarily of upper Miocene to Pleistocene white, pale gray, and pale greenish gray clayey nannofossil ooze and chalk. Carbonate content increases downhole. The sediments are generally very soft and have been deformed by drilling so that original sedimentary structures are not generally observable. These carbonates are interpreted as a pelagic submarine valley-fill deposited above the CCD. The clay component of samples analyzed from this unit averages about 20% kaolinite, 15% chlorite, 45% illite, and 20% smectite. However, the clay profiles for samples collected from Cores 103-638B-7R through 103-638B-12R are poor, making interpretation of clay mineral percentages tenuous in this section.

Included within the carbonates of lithologic Unit I are two discrete layers of firm clay with less than 5% carbonate (Samples 103-638B-10R-2, 90–105 cm, and 103-638B-18R-1, 0–65 cm). The former layer is green with black, zeolite-rich laminae; the latter is reddish brown. Both layers include a jumble of clasts that have the appearance of debris flows; they are certainly redeposited because they contain Cretaceous microfossils (see "Site 638" chapter; Boillot, Winterer, et al., 1987). The reddish brown clay layer in Core 103-638B-18R contains about 0%–20% kaolinite and chlorite, 30% illite, 30% smectite, and 15%–35% palygorskite. The clay layer in Core 103-638B-10R was not sampled.

Lithologic Unit II (183.6–298.4 mbsf) is divided into two subunits. The upper subunit (Subunit IIA) consists of upper Barremian bioturbated and weakly laminated micritic limestone and marlstone, interbedded with 1- to 5-cm-thick couplets of silty claystone and marlstone rich in terrigenous material. The former are interpreted as pelagic sediments deposited above the CCD, and the couplets are probably turbidites, resembling T_d-T_e beds of the Bouma sequence. The lower subunit (Subunit IIB) consists of alternations of Valanginian-Hauterivian bioturbated nannofossil marlstone and more clay-rich nannofossil marlstone, with many slumped intervals. Of the relatively few samples taken for clay analyses from Unit II, most are from calcareous claystone and marlstone sediment types. Clay mineralogies vary considerably, but average about 20% kaolinite + chlorite, 40% illite, and 40% smectite. Kaolinite and chlorite could not be differentiated on many of the profiles but, where possible, they appear to be present in roughly equal amounts.

Lithologic Unit III (298.4–547.2 mbsf) is distinguished by the occurrence of abundant terrigenous turbidites and is of Valanginian age. It is divided into two subunits. The upper subunit (Subunit IIIA) consists of silty claystone and nannofossil marlstone couplets, with several layers of sandstone turbidites up to 10 cm thick. The lower subunit (Subunit IIIB) is characterized by thick beds of terrigenous medium- to coarse-grained arkosic sandstone, interbedded with minor siltstone/claystone and marlstone (for detailed petrographic descriptions of the sandstone layers see Johnson, this volume; Winterer et al., this volume). The sandstone and siltstone/claystone layers are interpreted as turbidites and the marlstone as pelagic material deposited during the time intervals between turbidity current events. Clay samples from this unit were collected primarily from the claystone intervals. The clay mineralogy of these samples averages 20% kaolinite, 20% chlorite, 45% illite, and 15% smectite.

Site 639

Site 639 was situated close to Site 638 (Fig. 1) in order to penetrate through the syn-rift sequence into the pre-rift carbonate platform sequence and crystalline basement—an objective we failed to achieve at Site 638 because of hole instability. A total of six holes was drilled at Site 639; the operational reasons behind this are in the "Site 639" chapter (Boillot, Winterer, et al., 1987). By piecing together the sections at these holes, the resulting generalized stratigraphic section can be divided into six lithologic units. These lithologic units are described only briefly here (see "Site 639" chapter for further details; Boillot, Winterer, et al., 1987). Few samples were taken for clay mineralogic analyses at this site, largely because of the poor core recovery.

Lithologic Unit I consists of Neogene clayey nannofossil ooze, nannofossil marl, and calcareous clay, occurring as vague, rhythmic alternations on a 10-cm to 2.5-m scale. These sediments are interpreted as pelagic carbonates probably deposited above the CCD. The more clay-rich intervals may represent increased influx of terrigenous material during Pliocene-Pleistocene glaciations, perhaps as distal turbidity flows or as nepheloid layers. Lithologic Unit I was cored in four of the six drill holes and was sampled for clay mineralogy analyses at three of these holes (Holes 639A, 639B, and 639D; see Fig. 4). The clay component of these sediments in the three holes averages about 10% kaolinite, 10% chlorite, 45% illite, and 35% smectite.

Lithologic Unit II consists of dark brown to light reddish brown clay, with clayey silt and limonite-stained sandy patches. It was recovered only in Hole 639C, and is dated as Paleocene-Eocene age by ichthyoliths (Doyle, this volume). A total of four samples from this unit were analyzed for clay mineralogy. These samples contain an average of about 30% illite, 20% smectite, 30% palygorskite, and smaller amounts of kaolinite (13%) and chlorite (7%).

Lithologic Unit III, recovered only in Hole 639A, consists of lower Valanginian, mottled, pale yellow, calpionellid-bearing marl and marlstone. Thin sandstone interbeds and clasts were probably deposited by low-density turbidity flows during what was otherwise a period of predominantly pelagic sedimentation. The clay component of samples analyzed from this unit consists of about 20% chlorite, 35% smectite, 45% illite, and little or no kaolinite (Fig. 4).

Lithologic Unit IV consists of dolomite, commonly fractured and vuggy, with internal sediments in fractures and vugs. Its age is uncertain, and no samples were taken for clay analyses.

Lithologic Unit V consists of Tithonian limestone, clayey limestone, marlstone, and sandstone. Only two samples were analyzed for clay mineralogy. Sample 103-639D-7R-2, 80–82 cm, a calcareous clay, consists of 9% kaolinite + chlorite, 13% smectite, and 78% illite. Sample 103-639D-8R-2, 14–16 cm, a siltstone, contains 5% kaolinite + chlorite, 62% smectite, and 33% illite. In both instances, kaolinite and chlorite could not be differentiated because of the overall minor quantities of those clay minerals in the samples.

Table 1. Leg 103 clay mineralogy data.

Sample	Unweighted peak area (cm^3)					Weighted peak area (cm^3)					
	Kaolinite + chlorite	Illite	Smectite	Palygorskite	Sepiolite	Kaolinite + chlorite	Illite	Smectite	Palygorskite	Sepiolite	Total
103-637A-6R-1, 56 cm	97.5	132	0	0	0	195	528	0	0	0	723
6R-3, 67 cm	756	483	441	0	0	1512	1932	441	0	0	3885
7R-1, 23 cm	562.5	432	621	0	0	1125	1728	621	0	0	3474
7R-2, 70 cm	153	112	207	0	0	306	448	207	0	0	961
8R-2, 41 cm	350	258	0	0	0	700	1032	0	0	0	1732
8R-3, 65 cm	544	420	1155	0	0	1088	1680	1155	0	0	3923
8R-3, 77 cm	600	432	708	0	0	1200	1728	708	0	0	3636
8R-3, 84 cm	578	427.5	475	0	0	1156	1710	475	0	0	3341
8R-3, 94 cm	607.5	456	396	0	0	1215	1824	396	0	0	3435
9R-1, 109 cm	442	299	520	0	0	884	1196	520	0	0	2600
9R-2, 52 cm	540	384	828	0	0	1080	1536	828	0	0	3444
9R-2, 74 cm	724.5	430	0	0	0	1449	1720	0	0	0	3169
10R-1, 53 cm	502.5	357.5	845	0	0	1005	1430	845	0	0	3280
10R-2, 4 cm	180.5	104.5	156	0	0	361	418	156	0	0	935
11R-1, 67 cm	621	434	1170	0	0	1242	1736	1170	0	0	4148
12R-1, 28 cm	168	99	0	0	0	336	396	0	0	0	732
12R-2, 78 cm	608	390	828	0	0	1216	1560	828	0	0	3604
13R-2, 24 cm	528	288	0	0	0	1056	1152	0	0	0	2208
13R-2, 32 cm	600	432	360	0	0	1200	1728	360	0	0	3288
13R-2, 56 cm	273	192	427.5	0	0	546	768	427.5	0	0	1741.5
14R-1, 95 cm	585	272	0	0	0	1170	1088	0	0	0	2258
14R-2, 8 cm	289	148.5	406	0	0	578	594	406	0	0	1578
16R-1, 75 cm	598.5	315	520	0	0	1197	1260	520	0	0	2977
16R-2, 114 cm	153	95	140	0	0	306	380	140	0	0	826
17R-1, 83 cm	481	325	1248	0	0	962	1300	1248	0	0	3510
17R-1, 95 cm	624	72	650	0	0	1248	288	650	0	0	2186
17R-1, 105 cm	584	324.5	745.5	0	0	1168	1298	745.5	0	0	3211.5
17R-1, 118 cm	700	364	180	0	0	1400	1456	180	0	0	3036
17R-3, 88 cm	230	152	480	0	0	460	608	480	0	0	1548
19R-1, 73 cm	512	342	1105	0	0	1024	1368	1105	0	0	3497
19R-2, 83 cm	228	104	319	0	0	456	416	319	0	0	1191
19R-2, 120 cm	536	285	837	0	0	1072	1140	837	0	0	3049
20R-1, 41 cm	190	100	318	0	0	380	400	318	0	0	1098
20R-1, 114 cm	756	493.5	715.5	0	0	1512	1974	715.5	0	0	4201.5
20R-6, 86 cm	510	336	1364	0	0	1020	1344	1364	0	0	3728
21R-1, 26 cm	120	410	575	420	0	240	1640	575	2100	0	4555
21R-1, 71 cm	76.5	297.5	855.5	553.5	935	153	1190	855.5	2767.5	4675	9641
21R-6, 107 cm	216	395	855	700	1120	432	1580	855	3500	5600	11967
22R-1, 60 cm	258.5	660	1995	1665	1512	517	2640	1995	8325	7560	21037
103-638B-1R-2, 35 cm	360	240.5	465.5	0	0	720	962	465.5	0	0	2147.5
1R-2, 108 cm	285	185	800	0	0	570	740	800	0	0	2110
1R-4, 75 cm	154	99	193.5	0	0	308	396	193.5	0	0	897.5
2R-5, 75 cm	161.5	104	215	0	0	323	416	215	0	0	954
3R-1, 134 cm	176	75	175.5	0	0	352	300	175.5	0	0	827.5
4R-4, 72 cm	123.5	76	216	0	0	247	304	216	0	0	767
7R-1, 60 cm	42.5	51	0	0	0	85	204	0	0	0	289
10R-2, 25 cm	120	70	0	0	0	240	280	0	0	0	520
11R-2, 91 cm	93.5	105	0	0	0	187	420	0	0	0	607
12R-1, 50 cm	161.5	96	0	0	0	323	384	0	0	0	707
13R-3, 51 cm	178.5	105	141	0	0	357	420	141	0	0	918
15R, CC (2 cm)	90	52.5	140	0	0	180	210	140	0	0	530
17R-1, 7 cm	88	44	136.5	0	0	176	176	136.5	0	0	488.5
18R-1, 5 cm	0	168	836	178.5	0	0	672	836	892.5	0	2400.5
18R-1, 15 cm	192	126.5	587.5	55	0	384	506	587.5	275	0	1752.5
18R-1, 30 cm	385	270	994.5	99	0	770	1080	994.5	495	0	3339.5
18R-2, 40 cm	518.5	228	1005	0	0	1037	912	1005	0	0	2954
18R-3, 65 cm	136.5	85	250	0	0	273	340	250	0	0	863
20R-3, 52 cm	110.5	315	1035	0	0	221	1260	1035	0	0	2516
21R-3, 122 cm	56	188.5	647.5	0	0	112	754	647.5	0	0	1513.5
23R-1, 62 cm	1060	494	297	0	0	2120	1976	297	0	0	4393
23R-1, 77 cm	60	140	589	0	0	120	560	589	0	0	1269
25R-5, 25 cm	192	210	1040	0	0	384	840	1040	0	0	2264
25R-5, 55 cm	133	225	851	0	0	266	900	851	0	0	2017
27R-3, 65 cm	147	99	300	0	0	294	396	300	0	0	990
29R-2, 70 cm	126	148	1300	0	0	252	592	1300	0	0	2144
31R-3, 75 cm	970	377	517	0	0	1940	1508	517	0	0	3965
33R-4, 35 cm	88	149.5	758.5	0	0	176	598	758.5	0	0	1532.5
35R-1, 117 cm	306	132	0	0	0	612	528	0	0	0	1140
35R-1, 123 cm	1251	545	1080	0	0	2502	2180	1080	0	0	5762
35R-4, 62 cm	927	429	468	0	0	1854	1716	1872	0	0	5442
35R-4, 74 cm	1305	540	460	0	0	2610	2160	460	0	0	5230
37R-1, 38 cm	900	345	651	0	0	1800	1380	651	0	0	3831
42R-3, 33 cm	960	451	416.5	0	0	1920	1804	416.5	0	0	4140.5
44R-2, 23 cm	1159	450	560	0	0	2318	1800	560	0	0	4678
45R-2, 25 cm	756.5	440	?	0	0	1513	1760	?	0	0	3273
103-638C-1R-1, 96 cm	960	416.5	457.5	0	0	1920	1666	457.5	0	0	4043.5
3R-2, 41 cm	883.5	440	450.5	0	0	1767	1760	450.5	0	0	3977.5
3R-2, 145 cm	663	301.5	312	0	0	1326	1206	312	0	0	2844
5R-2, 20 cm	935	621.5	875	0	0	1870	2486	875	0	0	5231
5R-2, 56 cm	798	450	3975	0	0	1596	1800	3975	0	0	7371

Table 1 (continued).

Clay mineral percentage					Peak height (cm)		Clay mineral percentage	
Kaolinite + chlorite	Illite	Smectite	Palygorskite	Sepiolite	Kaolinite	Chlorite	Kaolinite	Chlorite
27	73	0	0	0	?	?	?	?
39	50	11	0	0	77	49	24	15
32	50	18	0	0	71	47	19	13
32	47	21	0	0	?	?	?	?
40	60	0	0	0	50	35	24	16
28	43	29	0	0	59	43	16	12
33	48	19	0	0	?	?	?	?
35	51	14	0	0	65	49	20	15
35	53	12	0	0	75	42	22	13
34	46	20	0	0	50	38	19	15
31	45	24	0	0	74	42	20	11
46	54	0	0	0	?	?	?	?
30	44	26	0	0	70	49	18	12
38	45	17	0	0	18	13	22	16
30	42	28	0	0	62	46	17	13
46	54	0	0	0	24	17	27	19
34	43	23	0	0	74	55	20	14
48	52	0	0	0	68	42	30	18
36	53	11	0	0	73	46	22	14
31	44	25	0	0	35	20	20	11
52	48	0	0	0	101	59	33	19
36	38	26	0	0	33	20	22	14
40	42	18	0	0	?	?	?	?
37	46	17	0	0	?	?	?	?
27	37	36	0	0	75	40	18	9
57	13	30	0	0	71	44	35	22
36	41	23	0	0	76	47	22	14
46	48	6	0	0	?	?	?	?
30	39	31	0	0	22	12	19	11
29	39	32	0	0	60	35	18	11
38	35	27	0	0	24	14	24	14
35	37	28	0	0	68	44	21	14
35	36	29	0	0	21	17	19	16
36	47	17	0	0	?	?	?	?
27	36	37	0	0	57	35	17	10
5	36	13	46	0	17	22	2	3
2	12	9	29	48	25	29	1	1
4	13	7	29	47	24	31	2	2
2	13	9	40	36	39	27	1	1
33	45	22	0	0	44	34	19	14
27	35	38	0	0	37	28	15	12
34	44	22	0	0	14	11	19	15
34	44	22	0	0	17	12	20	14
43	36	21	0	0	?	?	?	?
32	40	28	0	0	13	10	18	14
29	71	0	0	0	9	10	14	15
46	54	0	0	0	?	?	?	?
31	69	0	0	0	?	?	?	?
46	54	0	0	0	15	12	26	20
39	46	15	0	0	18	10	25	14
34	40	26	0	0	13	9	20	14
36	36	28	0	0	13	7	23	13
0	28	35	37	0	0	0	0	0
22	29	34	15	0	32	18	14	8
23	32	30	15	0	58	20	17	6
35	31	34	0	0	62	43	21	14
32	39	29	0	0	?	?	?	?
9	50	41	0	0	?	?	?	?
7	50	43	0	0	?	?	?	?
48	45	7	0	0	?	?	?	?
10	44	46	0	0	?	?	?	?
17	37	46	0	0	19	21	8	9
13	45	42	0	0	14	15	6	7
30	40	30	0	0	8	8	15	15
12	27	61	0	0	22	10	8	4
49	38	13	0	0	?	?	?	?
11	39	50	0	0	?	?	?	?
54	46	0	0	0	29	28	27	27
43	38	19	0	0	83	86	21	22
34	32	34	0	0	90	93	17	17
50	41	9	0	0	74	55	28	22
47	36	17	0	0	89	90	23	24
46	44	10	0	0	86	84	23	23
50	38	12	0	0	84	86	25	25
46	54	?	0	0	84	84	23	23
48	41	11	0	0	127	137	23	25
45	44	11	0	0	94	86	23	22
47	42	11	0	0	86	81	24	23
36	47	17	0	0	105	97	19	17
22	23	54	0	0	112	109	11	11

Table 1 (continued).

	Unweighted peak area (cm^3)					Weighted peak area (cm^3)					
Sample	Kaolinite + chlorite	Illite	Smectite	Palygorskite	Sepiolite	Kaolinite + chlorite	Illite	Smectite	Palygorskite	Sepiolite	Total
103-638C-8R-1, 116 cm	1270.5	495	4292	0	0	2541	1980	4292	0	0	8813
8R-1, 125 cm	1190	700	540	0	0	2380	2800	540	0	0	5720
9R-2, 16 cm	1208	822	973.5	0	0	2416	3288	973.5	0	0	6677.5
12R-1, 65 cm	756.5	498	235	0	0	1513	1992	235	0	0	3740
14R-1, 68 cm	1521	696	569.5	0	0	3042	2784	569.5	0	0	6395.5
14R-2, 49 cm	1521	1147.5	904.5	0	0	3042	4590	904.5	0	0	8536.5
103-639A-1R-1, 118 cm	232.5	217	651	0	0	465	868	651	0	0	1984
2R-5, 40 cm	72	112.5	532.5	0	0	144	450	532.5	0	0	1126.5
3R-1, 22 cm	210	240	586.5	0	0	420	960	586.5	0	0	1966.5
3R-4, 57 cm	154	132	632.5	0	0	308	528	632.5	0	0	1468.5
4R-1, 20 cm	851.5	627	2146.5	0	0	1703	627	2146.5	0	0	4476.5
4R-1, 29 cm	648	350	759	0	0	1296	1400	759	0	0	3455
5R-1, 54 cm	455	296	1232	0	0	910	1184	1232	0	0	3326
6R-1, 79 cm	243	265	585	0	0	486	1060	585	0	0	2131
6R-2, 100 cm	235	325	1014	0	0	470	1300	1014	0	0	2784
7R-2, 15 cm	188	228	712.5	0	0	376	912	712.5	0	0	2000.5
8R-1, 73 cm	175.5	176	562.5	0	0	351	704	562.5	0	0	1617.5
8R-2, 64 cm	275	390	899	0	0	550	1560	899	0	0	3009
103-639B-1R-5, 46 cm	165	150	273	0	0	330	600	273	0	0	1203
103-639C-2R-1, 36 cm	721	575	2436	221	0	1442	2300	2436	1105	0	7283
2R-1, 61 cm	1117.5	851.5	1245.5	176	0	2235	1703	1245.5	880	0	6063.5
2R-1, 104 cm	186	322	1085	600	0	372	1288	1085	3000	0	5745
2R-2, 17 cm	822	948	1533	550	0	1644	3792	1533	2750	0	9719
103-639D-1W-1, 43 cm	352	380	938	0	0	704	1520	938	0	0	3162
7R-2, 82 cm	266.5	1200	837	0	0	533	4800	837	0	0	6170
8R-1, 14 cm	120	378	2821.5	0	0	240	1512	2821.5	0	0	4573.5
103-640A-1R-1, 51 cm	162.5	185	1537	180	0	325	740	1537	900	0	3502
1R-1, 95 cm	280	200	1275	204	0	560	800	1275	1020	0	3655
1R-1, 118 cm	420	588	2915	1175	0	840	2352	2915	5875	0	11982
2R-1, 72 cm	658	360	1675	495	0	1316	1440	1675	2475	0	6906
2R-1, 128 cm	279.5	282	1091.5	637	0	559	1128	1091.5	3185	0	5963.5
2R-2, 25 cm	585	473	2146.5	587.5	0	1170	1892	2146.5	2937.5	0	8146
2R-2, 37 cm	12	221	2400	216	0	24	884	2400	1080	0	4388
2R-2, 49 cm	66	493.5	2914	0	0	132	1974	2914	0	0	5020
3R-2, 59 cm	60	180	559	0	0	120	720	559	0	0	1399
4R-1, 60 cm	123.5	186	924	0	0	247	744	924	0	0	1915
6R-1, 46 cm	620	455	2131.5	0	0	1240	1820	2131.5	0	0	5191.5
6R-1, 85 cm	238	297	1425	0	0	476	1188	1425	0	0	3089
7R-1, 64 cm	603.5	583	2843.5	0	0	1207	2332	2843.5	0	0	6382.5
8R-1, 37 cm	810	564	1617	0	0	1620	2256	1617	0	0	5493
103-641A-1X-2, 26 cm	675	636	3551	0	0	1350	2544	3551	0	0	7445
1X-3, 56 cm	480	461.5	1736	0	0	960	1846	1736	0	0	4542
3X-2, 135 cm	368	188	984	0	0	736	752	984	0	0	2472
4X-1, 44 cm	345	203.5	897	0	0	690	814	897	0	0	2401
5X-1, 62 cm	196	112.5	1788.5	0	0	392	450	1788.5	0	0	2630.5
5X-2, 95 cm	525	269.5	2660	0	0	1050	1078	2660	0	0	4788
6X-3, 50 cm	456	266	2420.5	0	0	912	1064	2420.5	0	0	4396.5
6X-5, 62 cm	378	174	1192.5	0	0	756	696	1192.5	0	0	2644.5
6X-7, 5 cm	560	282	2835	0	0	1120	1128	2835	0	0	5083
103-641C-1R-1, 142 cm	0	96	774	149.5	0	0	384	774	747.5	0	1905.5
2R-4, 22 cm	67.5	294	1920	168	0	135	1176	1920	840	0	4071
2R-5, 46 cm	81	304	1564	75	0	162	1216	1564	375	0	3317
3R-2, 39 cm	108	370	717.5	0	0	216	1480	717.5	0	0	2413.5
3R-3, 9 cm	65	323	2218.5	0	0	130	1292	2218.5	0	0	3640.5
4R-2, 57 cm	49.5	301	2266	0	0	99	1204	2266	0	0	3569
4R-2, 60 cm	121	595	3822	0	0	242	2380	3822	0	0	6444
4R-2, 63 cm	93.5	595	4303.5	0	0	187	2380	4303.5	0	0	6870.5
4R-4, 64 cm	78	456	2322	0	0	156	1824	2322	0	0	4302
6R-1, 12 cm	80	234	1584	0	0	160	936	1584	0	0	2680
6R-2, 52 cm	54	228	2777.5	0	0	108	912	2777.5	0	0	3797.5
6R-2, 60 cm	82.5	440	1815	0	0	165	1760	1815	0	0	3740
6R-2, 88 cm	28	210	2134	0	0	56	840	2134	0	0	3030
6R-3, 78 cm	65	514.5	3473	0	0	130	514.5	3473	0	0	4117.5
6R-3, 80 cm	24	175	1802	0	0	48	700	1802	0	0	2550
7R-1, 51 cm	82.5	372	1209	0	0	165	1488	1209	0	0	2862
8R-3, 51 cm	165	297	1934.5	0	0	330	1188	1934.5	0	0	3452.5
9R-1, 112 cm	120	422.5	1903.5	0	0	240	1690	1903.5	0	0	3833.5
9R-2, 112 cm	85	370.5	1955	0	0	170	1482	1955	0	0	3607
10R-3, 104 cm	0	165	779	0	0	0	660	779	0	0	1439
11R-1, 81 cm	78	378	1200	0	0	156	1512	1200	0	0	2868
11R-3, 54 cm	59.5	160	304.5	0	0	119	640	304.5	0	0	1063.5
12R-2, 97 cm	52	126	340	0	0	104	504	340	0	0	948
12R-3, 50 cm	49	379.5	1260	0	0	98	1518	1260	0	0	2876
13R-2, 111 cm	60	240	1350	0	0	120	960	1350	0	0	2430
13R-4, 78 cm	67.5	483	2830.5	0	0	135	483	2830.5	0	0	3448.5
14R-3, 103 cm	55	255	787.5	0	0	110	1020	787.5	0	0	1917.5
15R-1, 55 cm	60	234	722	0	0	120	936	722	0	0	1778
15R-3, 72 cm	45	280	1386.5	0	0	90	1120	1386.5	0	0	2596.5
16R-2, 37 cm	71.5	312	1563.5	0	0	143	1248	1563.5	0	0	2954.5

Table 1 (continued).

Clay mineral percentage					Peak height (cm)		Clay mineral percentage	
Kaolinite + chlorite	Illite	Smectite	Palygorskite	Sepiolite	Kaolinite	Chlorite	Kaolinite	Chlorite
29	22	49	0	0	110	89	16	13
42	49	9	0	0	124	121	22	20
36	49	15	0	0	76	68	19	17
41	53	6	0	0	85	69	23	18
48	43	9	0	0	82	50	30	18
36	54	10	0	0	85	75	19	17
23	45	33	0	0	36	29	13	10
13	40	47	0	0	25	17	8	5
21	49	30	0	0	47	39	12	9
21	36	43	0	0	27	18	13	8
38	14	48	0	0	84	50	24	14
37	41	22	0	0	127	75	23	14
27	36	37	0	0	55	67	15	12
23	50	27	0	0	?	5	?	23
17	47	36	0	0	?	5	?	17
19	45	36	0	0	?	7	?	19
22	43	35	0	0	?	3	?	22
18	52	30	0	0	?	6	?	18
27	50	23	0	0	21	19	14	13
20	32	33	15	0	62	31	13	7
37	28	20	15	0	93	47	24	13
7	22	19	52	0	35	25	4	3
17	39	16	28	0	83	53	11	6
22	48	30	0	0	80	56	13	9
9	78	13	0	0	?	?	?	?
5	33	62	0	0	?	?	?	?
9	21	44	26	0	35	25	5	4
15	22	35	28	0	57	27	10	5
7	20	24	49	0	67	41	4	3
19	21	24	36	0	65	44	11	8
9	19	18	54	0	59	31	6	3
15	23	26	36	0	103	72	9	6
<1	20	55	25	0	?	?	?	?
3	39	58	0	0	?	?	?	?
9	51	40	0	0	?	?	?	?
13	39	48	0	0	18	20	6	7
24	35	41	0	0	71	69	12	12
15	39	46	0	0	30	35	7	8
19	36	45	0	0	61	60	10	9
30	41	29	0	0	98	93	15	15
18	34	48	0	0	124	87	11	7
21	41	38	0	0	110	77	12	9
30	30	40	0	0	100	69	18	12
29	34	37	0	0	63	46	17	12
15	17	68	0	0	8	0	15	0
22	23	55	0	0	11	0	22	0
21	24	55	0	0	9	0	21	0
29	26	45	0	0	9	0	29	0
22	22	56	0	0	12	0	22	0
0	20	41	39	0	0	0	0	0
3	29	47	21	0	0	0	0	0
5	37	47	11	0	0	0	0	0
9	61	30	0	0	0	0	0	0
4	35	61	0	0	0	0	0	0
3	34	63	0	0	0	0	0	0
4	37	59	0	0	0	0	0	0
3	35	62	0	0	0	0	0	0
4	42	54	0	0	0	0	0	0
6	35	59	0	0	0	0	0	0
3	24	73	0	0	0	0	0	0
4	47	49	0	0	0	0	0	0
2	28	70	0	0	0	0	0	0
3	13	84	0	0	0	0	0	0
2	27	71	0	0	0	0	0	0
6	52	42	0	0	0	0	0	0
10	34	56	0	0	0	0	0	0
6	44	50	0	0	0	0	0	0
5	41	54	0	0	0	0	0	0
0	46	54	0	0	0	0	0	0
5	53	42	0	0	0	0	0	0
11	60	29	0	0	0	0	0	0
11	53	36	0	0	0	0	0	0
3	53	44	0	0	0	0	0	0
5	40	55	0	0	0	0	0	0
4	14	82	0	0	0	0	0	0
6	53	41	0	0	0	0	0	0
7	53	40	0	0	0	0	0	0
4	43	53	0	0	0	0	0	0
5	42	53	0	0	0	0	0	0

Table 2. Characteristic peaks and correction factors for clay minerals detected in samples from Leg 103.

Mineral	Main peak(s) used for identification (° 2θ)	Correction factor
Kaolinite	12.4/24.88	2
Illite	8.8	4
Chlorite	6.2/12.4/25.15	2
[a]Smectite, glycolated	5.0–5.5	1
Palygorskite	8.5	5
Sepiolite	7.3	5

[a] Smectite is used here as a blanket term for all smectites and illite-smectite interlayers that expand to give a 17Å, 5.0°–5.5° 2θ peak on glycolation.

Lithologic Unit VI, termed the "problematic interval" by the shipboard sedimentologists, includes a wide variety of very poorly recovered sedimentary, igneous, and metamorphic rocks (see "Site 639" chapter; Boillot, Winterer, et al., 1987). No samples were taken for clay analyses.

Site 640

Drilling at Site 640 was on a buried north-trending ridge near the western edge of the Galicia margin that brings "acoustic basement" (actually a zone of incoherent reflectors) close to the seafloor (Fig. 1). Only a few cores were drilled into this acoustically incoherent unit (Cores 103-640A-5R through 103-640A-9R), to test the hypothesis that the deeper S reflector within "acoustic basement" represents the boundary between ductile and brittle crust, where listric faults merge at depth (Montadert et al., 1979b; Chenet et al., 1982). The section from 0 to 145 mbsf was washed without coring. The recovered sediments below that depth are divided into three lithologic units (see "Site 640" chapter; Boillot, Winterer, et al., 1987). Clay samples were analyzed from all three units. Figure 5 shows the downhole trends in clay mineralogy at this site.

Lithologic Unit I (145–157 mbsf) consists of pelagic brown and yellowish brown clay, interpreted to have accumulated below the CCD. The clay is faintly mottled and with diffuse banding on a scale of 1–10 cm. Shipboard smear slide analysis shows the sediment to be composed principally of recrystallized clay minerals, with trace amounts of quartz silt and carbonate rhombs. Based on ichthyoliths, this unit is of Paleocene age. The clay component of the samples analyzed from this unit averages about 20% illite, 30% smectite, and 35% palygorskite, with smaller amounts of kaolinite and chlorite (totaling about 10%–15%).

Lithologic Unit II (157–165 mbsf) consists of Albian-Aptian olive-gray clay and white and olive-yellow clayey ooze and is interpreted as a pelagic deposit. The few clay samples analyzed from this unit consist dominantly of smectite (about 55%) and illite (about 40%), with only a few percent kaolinite and chlorite.

Lithologic Unit III (165–232 mbsf) consists of Barremian interbedded dark gray calcareous claystone and marlstone and white clayey chalk (Subunit IIIA), overlying Hauterivian sandstone, limestone, and marlstone (Subunit IIIB). This unit is interpreted as being a sequence of interbedded distal terrigenous turbidites and pelagic and hemipelagic sediments. Only calcareous clay and marl were sampled from this unit for clay mineralogic analyses. The samples consist of an average of 10% kaolinite, 10% chlorite, 40% illite, and 40% smectite.

Site 641

Site 641 was situated upslope and east of Site 638 (Fig. 1), so that drilling would supplement data from Site 638 by coring the upper part of the syn-rift and the lower part of the post-rift sections. A major objective at Site 641 was to date the break-up unconformity on the Galicia margin. Cores were collected from two holes at this site: Hole 641A, cored from 0–63.6 mbsf, and Hole 641C, cored from 150.9–305.2 mbsf. The interval from 63.6 to 150.9 mbsf was not cored. The recovered sediments are divided into six lithologic units. Clay profiles for samples analyzed from this site are given in Figures 6 (Hole 641A) and 7 (Hole 641C).

Lithologic Unit I (0–53.6 mbsf), cored only in Hole 641A, consists principally of uniform, structureless, brown and dark grayish brown Upper Cretaceous (Turonian-Maestrichtian) clay that becomes redder downhole. It is interpreted as being a pelagic clay, accumulating slowly in an oxygenated environment below the CCD. The uppermost 15 m of this unit also includes slumped and highly disturbed intervals of brown clay, marl, and calcareous ooze of early Pleistocene age (Moullade et al., this volume). The clay mineralogy of brown clay samples from this unit averages 20% kaolinite + chlorite, 30% illite, and 50% smectite. Smectite increases downhole at the expense of illite; kaolinite is not detected below Core 103-641A-4X. None of the samples contain detectable quantities of palygorskite.

Below lithologic Unit I, Hole 641A is divided into lithologic Unit II (53.6–53.9 mbsf) and lithologic Subunit IIIA (53.9–>63.6 mbsf). Lithologic Unit II consists of black zeolitic clay with approximately 10% organic matter (Dunham et al., this volume). Lithologic Subunit IIIA consists of upper Albian–Cenomanian greenish gray calcareous clay and marl. No samples were taken from either of these units for clay analyses.

Sediments recovered from Hole 641C are divided into lithologic Subunit IIIB and Units IV through VI (Fig. 7). Subunit IIIB (<150.9–202.6 mbsf) consists of alternations of lower middle Albian black, dark green, organic-rich laminated claystone, with minor marlstone and very fine-grained sandstone and siltstone laminae. The subunit is characterized by its abundant black claystone layers. Lithologic Unit IV (202.6–218.4 mbsf) consists of upper Aptian greenish gray marlstone and calcareous claystone, with several interbeds of limestone conglomerate and coarse-grained calcarenite. The coarse-grained beds are probably turbidites. Lithologic Units V (218.4–250.6 mbsf) and VI (250.6–305.2 mbsf) consist of alternating intervals of thin-bedded, upper Barremian–lower Aptian greenish gray calcareous claystone and marlstone microturbidites, bioturbated and faintly laminated gray marlstone, and bioturbated, massive clayey limestone. Unit VI includes minor debris flows and sand turbidites, and is distinguished from Unit V by being richer in carbonate overall. Detailed descriptions of these sedimentary units are given in the "Site 641" chapter (Boillot, Winterer, et al., 1987).

All clay samples analyzed from Hole 641C contain only minor amounts of kaolinite and chlorite (0%–11%) (Fig. 7). Illite percentages range from 13% to 61%, averaging 40%; smectite ranges from 29% to 84%, averaging 55%. In general, the more carbonate-rich greenish gray calcareous claystone and marlstone samples contain greater amounts of illite and lesser amounts of smectite than do the darker gray or black claystone samples. Only samples from the uppermost portion of Subunit IIIB (Cores 103-641C-1R and 103-641C-2R) contain detectable amounts of palygorskite.

DISCUSSION AND CONCLUSIONS

Neogene Sediments

Neogene nannofossil marl, clayey nannofossil ooze, and calcareous clay were recovered at Hole 637A (lithologic Units I and II; 0–185 mbsf), Hole 638B (lithologic Unit I; 0–183.6 mbsf), and Hole 639A (lithologic Unit I). These calcareous sediments are interbedded with clay and silty clay terrigenous turbidites in

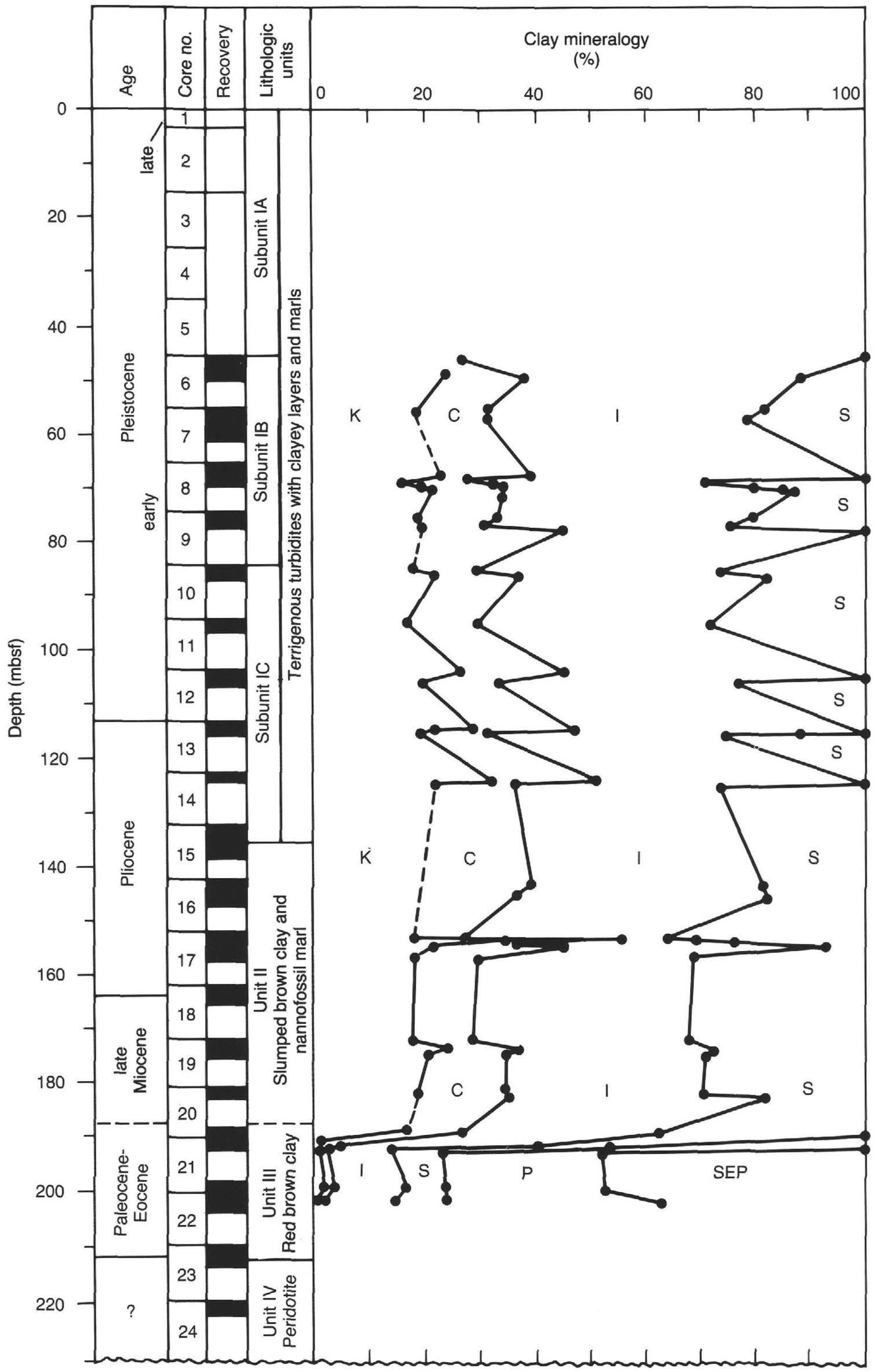

Figure 2. Age, core number and recovery (in black), lithologic units, and clay mineralogy of Site 637 (Hole 637A) samples. K = kaolinite; C = chlorite; I = illite; S = smectite, P = palygorskite; SEP = sepiolite. Age information from Moullade et al. (this volume).

lithologic Unit I of Hole 637A. The calcareous sediments primarily appear to be pelagic carbonates deposited above the CCD, though the more clay-rich intervals may represent increased influx of terrigenous material during Pliocene-Pleistocene glaciations, perhaps as distal turbidity flows or as nepheloid layers. The clay mineralogy of the calcareous sediments is similar at all sites: 10%–20% kaolinite, 10%–15% chlorite, 40%–50% illite, and 25%–35% smectite. Smectite percentages are related to the carbonate content of the sediments: the clayey nannofossil ooze and marl samples contain greater percentages of smectite than do the calcareous clays or the clay and silty clay turbidites. This suggests that, relative to the clay component of the background

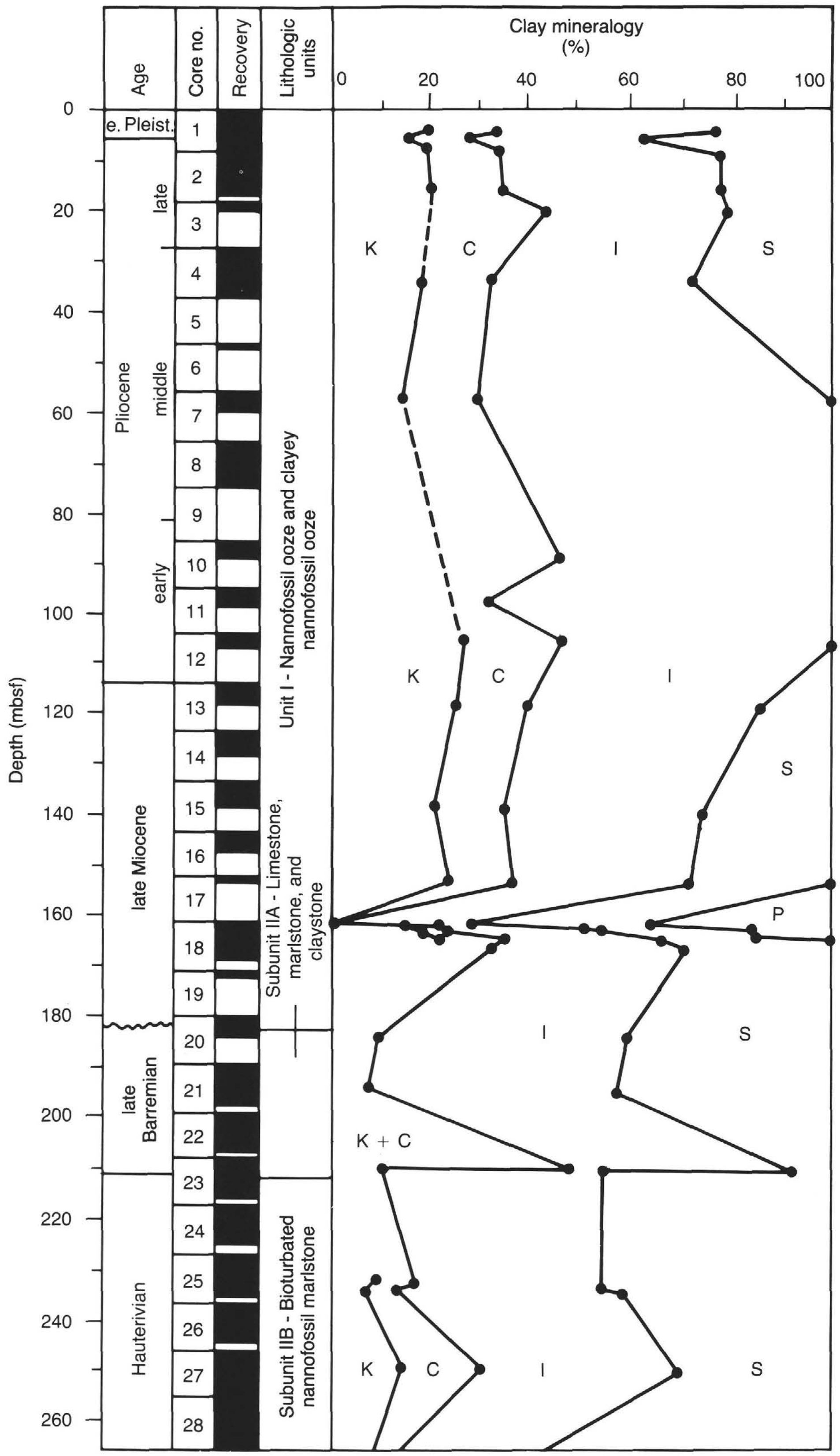

Figure 3. Age, core number and recovery (in black), lithologic units, and clay mineralogy of Site 638 (Holes 638B and 638C) samples. K = kaolinite; C = chlorite; I = illite; S = smectite; P = palygorskite. Age information from Moullade et al. (this volume). Core numbers from Hole 638C are prefaced by a "C."

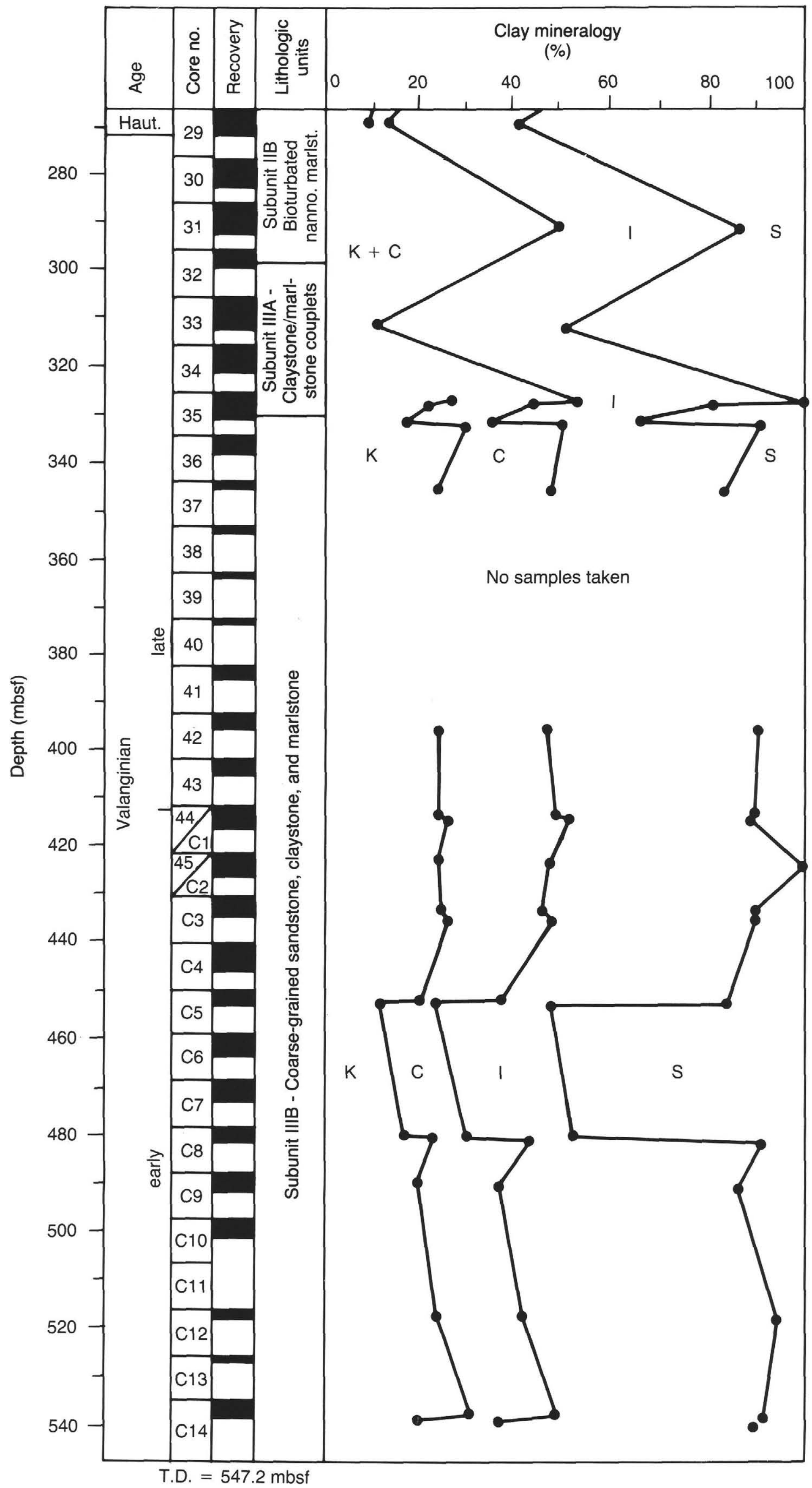

Figure 3 (continued).

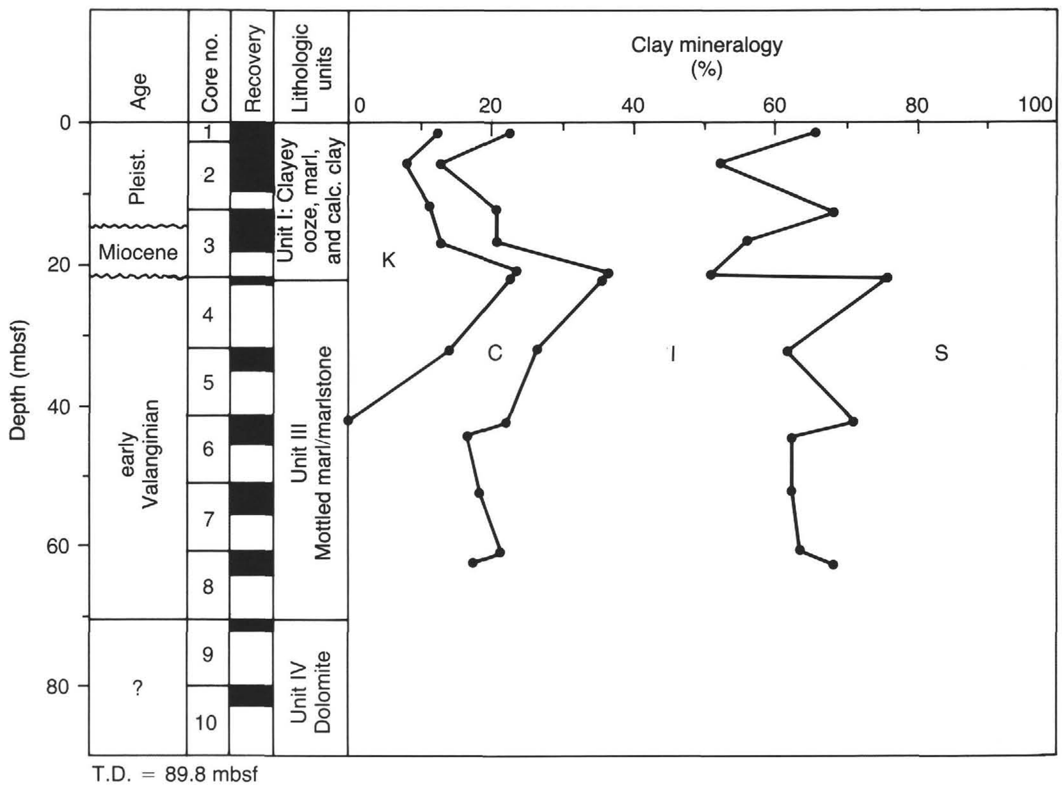

Figure 4. Age, core number and recovery (in black), lithologic units, and clay mineralogy of Site 639 (Hole 639A) samples. K = kaolinite; C = chlorite; I = illite; S = smectite. Age information from Moullade et al. (this volume).

pelagic sediment, the sources of fine-grained terrigenous sediment to the region contained little smectite during the Neogene.

These results are in general agreement with those of Chamley et al. (1979), who analyzed the clay mineralogy of Tertiary and Cretaceous sediments recovered at Site 398. Because the two studies used different peak analysis methods and different correction factors, direct comparison of the data sets is not possible. However, in their "Zone 1," which includes sediments of Oligocene-Pleistocene age, Chamley et al. (1979) documented an increasing abundance of illite and chlorite upsection. They attributed this to be the result of a generally cooling climate during that time period. This same abundance of illite and chlorite, relative to that in the underlying Cretaceous sediments, is seen in the Leg 103 samples. This is especially well documented in the silty clay and clay turbidites derived from the adjacent continent.

Initial shipboard interpretation of the depositional environment of the late Miocene–Pliocene age slumped brown clays and nannofossil marls at Site 637 (lithologic Unit II; 135–185 mbsf) suggested that the unit included weathering products from the underlying peridotite basement, slumped off the basement outcrop exposed a short distance to the west of the site (Fig. 1). The underlying brown clays of lithologic Unit III contain significant amounts of sepiolite, interpreted as being derived from alteration of the peridotite basement (see the following discussion). However, sepiolite is not found in any of the lithologic Unit II samples analyzed. This lack of sepiolite in lithologic Unit II suggests that the slumps in this unit do not incorporate significant weathering or alteration products from the basement ridge. Instead, the source of the slumped material in lithologic Unit II probably consists primarily of pelagic material deposited on top of the ridge.

Brown Clays

Brown, reddish brown, and grayish brown clays were recovered at all five Leg 103 sites: Hole 637A (lithologic Unit III; 185-212 mbsf), Hole 638B (as redeposited material within lithologic Unit I), Hole 639C (lithologic Unit II), Hole 640A (lithologic Unit I; 145-157 mbsf), and Hole 641A (lithologic Unit I; 0-53.6 mbsf).

Based on ichthyoliths, the brown clays at Holes 637A, 639C, and 640A are of Paleocene-Eocene age. The brown clay at Hole 638B could also be of similar age, as it was redeposited during the Neogene but contains reworked microfossils. All samples analyzed from the brown clays of these four holes contain significant percentages of palygorskite (15%-46%). Both illite and smectite occur in percentages ranging from 10% to 30%, whereas kaolinite and chlorite are present in smaller amounts (usually less than 10%). These similarities in age, lithology, and clay mineralogy suggest a common source for all these clay units.

The brown clay of lithologic Unit III at Hole 637A differs from those in Holes 638B, 639C, and 640A in that it also contains significant amounts (36%-48%) of sepiolite. This likely formed in association with the serpentinization and alteration of the immediately underlying peridotite basement ridge. (See Boillot et al. (1980) for a discussion of the alteration history of the basement ridge as determined from dredge haul samples collected on an exposed section of the ridge immediately west of Site 637.)

The brown clay recovered in Hole 641A appears to be different from that recovered at the other four sites. Though it is lithologically similar to the other brown clays, it is of Late Cretaceous age and does not contain detectable amounts of palygorskite. Clearly, the source of clay material to the Galicia margin

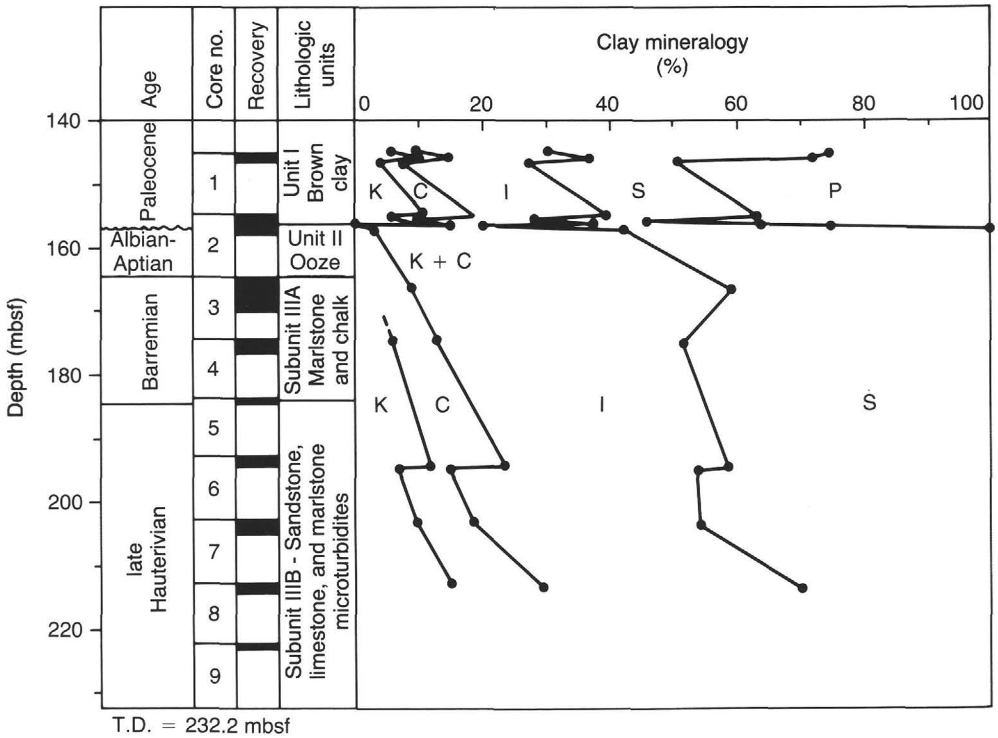

Figure 5. Age, core number and recovery (in black), lithologic units, and clay mineralogy of Site 640 (Hole 640A) samples. K = kaolinite; C = chlorite; I = illite; S = smectite, P = palygorskite. Age information from Moullade et al. (this volume).

during the Late Cretaceous contained relatively less palygorskite and relatively more smectite than during Paleocene-Eocene time (see Chamley et al. (1979) for a similar interpretation).

Cretaceous Sediments

The Cretaceous post- and syn-rift section drilled during Leg 103 was poorly sampled for clay analyses. Accordingly, only generalized conclusions can be reached about the source of clays in these sediments or the paleoenvironment. As is the case with the overlying Cenozoic section, the more calcareous, pelagic portions of the Cretaceous section contain greater amounts of smectite and lesser amounts of kaolinite and chlorite than the more terrigenous, clay-rich sediments. Apparently, the source of terrigenous fine-grained sediment throughout the syn- and post-rift period contained less smectite than that present in the pelagic material deposited between turbidity events. Also, the overall abundance of smectite in the Upper Cretaceous sediments is greater than that in the Tertiary sediments. As discussed by Chamley et al. (1979), this supports the interpretation of a warmer climate during Cretaceous time.

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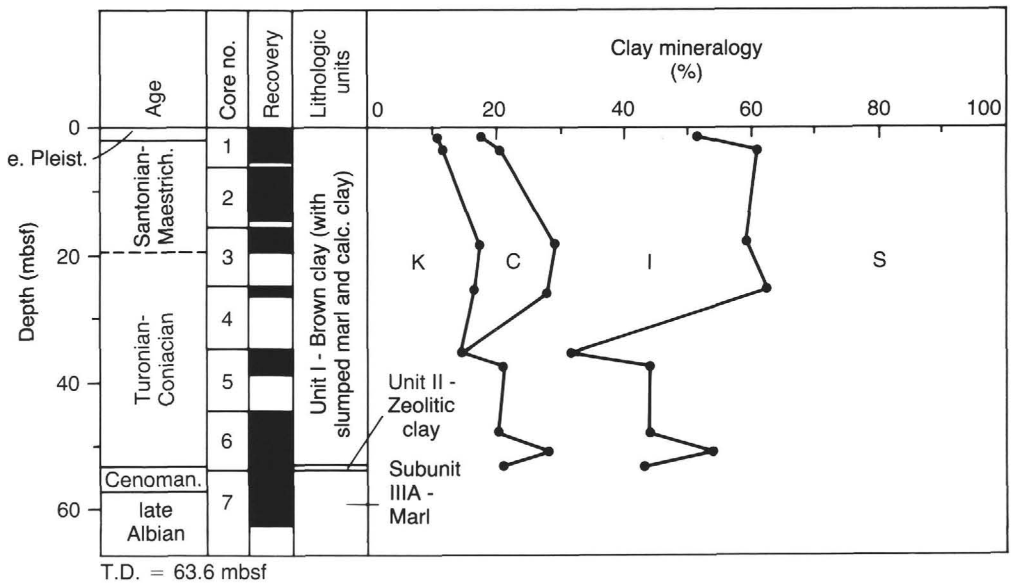

Figure 6. Age, core number and recovery (in black), lithologic units, and clay mineralogy of Hole 641A samples. K = kaolinite; C = chlorite; I = illite; S = smectite. Age information from Moullade et al. (this volume).

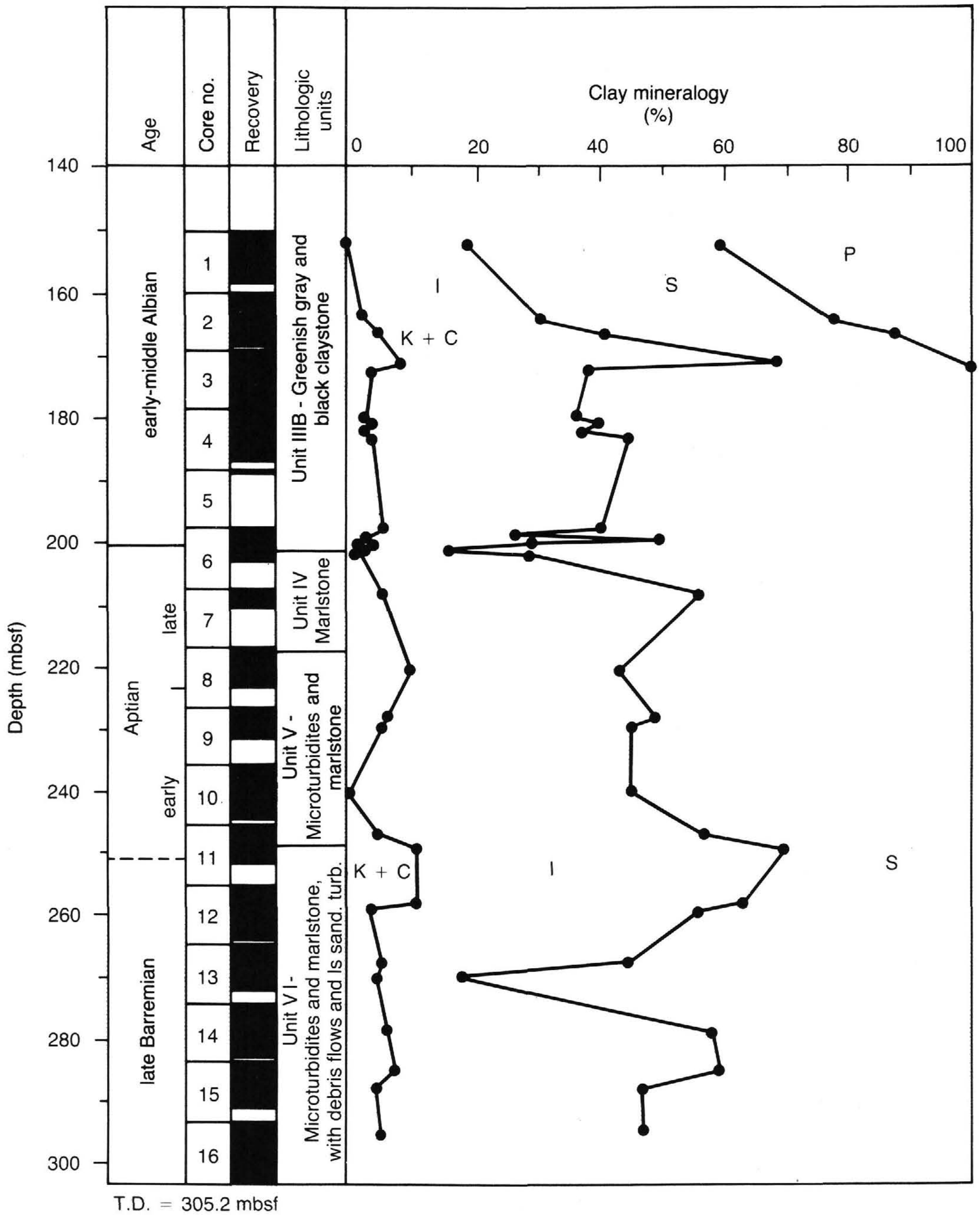

Figure 7. Age, core number and recovery (in black), lithologic units, and clay mineralogy of Hole 641C samples. K = kaolinite, C = chlorite, I = illite; S = smectite; P = palygorskite. Age information from Moullade et al. (this volume).