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53. PALEONTOLOGY OF THE CRETACEOUS OF THE CENTRAL KERGUELEN PLATEAU[1]

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ABSTRACT

A synthesis of the Cretaceous calcareous nannofossil, foraminifer, terrestrial and marine palynomorph, macrofauna, and macroflora data from drill sites on the Central Kerguelen Plateau indicates a complex sedimentary history spanning the Albian through the Maestrichtian. Nonmarine Albian sediments from the eastern part of the central plateau record the initial colonization and subsequent succession of plant communities on the basaltic islands left by edifice-building events during the Early Cretaceous. The eastern and northern parts of the central plateau foundered during the early Late Cretaceous. Disconformity-bounded sequences of pelagic calcareous sediment accumulated there throughout the Cenomanian to early Campanian. Following a widespread hiatus of sedimentation in the mid-Campanian, more continuous pelagic sedimentary sequences accumulated on the eastern and northern parts of the central plateau. This chalk sedimentation was abruptly terminated by the introduction of volcaniclastic debris flows in the northern area, but continued uninterrupted on the eastern margin of the central plateau. The western part of the central plateau entered the marine realm during the Cenomanian, although it remained at shallow (neritic) depths throughout the Cenomanian to Coniacian. A bryozoan-molluscan-foraminifer bank and bank-related facies complex developed in the western central plateau during the early Campanian. Sedimentation in this complex was interrupted during the mid-Campanian, but it resumed during the late Campanian. Water over the western bank facies belt remained very shallow throughout the late Campanian and Maestrichtian.

INTRODUCTION

The Kerguelen Plateau, stretching from 46° to 64°S, is the largest submarine plateau on Earth. This 2300-km-long structure lies within the Indian Ocean sector of the Southern Ocean to the north of Princess Elizabeth Land, Antarctica. Ocean Drilling Program (ODP) Leg 120 investigated the central part of the Kerguelen Plateau during March and April 1988. Sites 747, 748, and 750 were drilled during Leg 120 and yielded Cretaceous sedimentary sequences (Fig. 1). These sections provide the basis for a reconstruction of the paleontological history of the Central Kerguelen Plateau during the Albian through Maestrichtian.

Data for this paper were derived from an examination of several fossil groups, including calcareous nannofossils (Watkins, Chapter 21, this volume), planktonic foraminifers (Quilty, Chapter 22, this volume), benthic foraminifers (Quilty, Chapter 23, this volume), marine and terrestrial palynomorphs (Mohr and Gee, Chapters 17 and 19, this volume; Mao and Mohr, Chapter 20, this volume), macrofauna (Quilty, Chapter 24, this volume), and macroflora (Francis and Coffin, Chapter 18, this volume). Siliceous microfossils, including diatoms, radiolarians, and sponge spicules, occur rarely in these sections (Schlich, Wise, et al., 1989), but they are not the subject of any chapters in this volume.

Biostratigraphic control is based largely on calcareous nannofossils and palynomorphs, with auxiliary data provided by planktonic foraminifers. Calcareous nannofossil biostratigraphy for the Campanian and Maestrichtian is based on informal units delineated by a set of first and last appearance biohorizons of cosmopolitan and austral taxa (Watkins, this volume). Turonian through Santonian calcareous nannofossil biohorizons follow those of Sissingh (1977), as modified and enumerated by Perch-Nielsen (1985). Palynomorph ages are based on the zonation of Mao and Mohr (this volume) for the Campanian-Maestrichtian and compilation of published ranges for the Albian-Santonian (Mohr and Gee, Chapters 17 and 19, this volume). Three planktonic foraminifer zones are recognized for the Maestrichtian; pre-Maestrichtian age estimations are based on published taxon ranges (Quilty, Chapter 22, this volume). Age assignments for stage boundaries are those of Kent and Gradstein (1985).

Paleoenvironmental reconstruction is based primarily on information derived from benthic foraminifers and palynomorphs, with additional paleoceanographic data provided by calcareous nannofossils and planktonic foraminifers.

The basement of the Kerguelen Plateau consists of submarine and subaerial basalt flows and pyroclastic rocks. The basement basalts sampled by Leg 120 are transitional in composition between normal Indian Ocean mid-oceanic-ridge basalts (MORB) and Kerguelen Island oceanic-island basalts (OIB) (Schlich, Wise, et al., 1989). The basaltic basement appears to have been erupted largely before the middle Albian, based on K-Ar ages of 114 ± 1 Ma on dredge samples (Leclaire et al., 1987) and on whole-rock K-Ar ages of 111.5 ± 3.2 Ma on Sample 120-749C-15R-3 (Schlich, Wise, et al., 1989). These ages, taken in concert with an early Albian age of the basal sediment at Site 750, suggest that little time elapsed between the cessation of major edifice-building and the onset of sediment accumulation.

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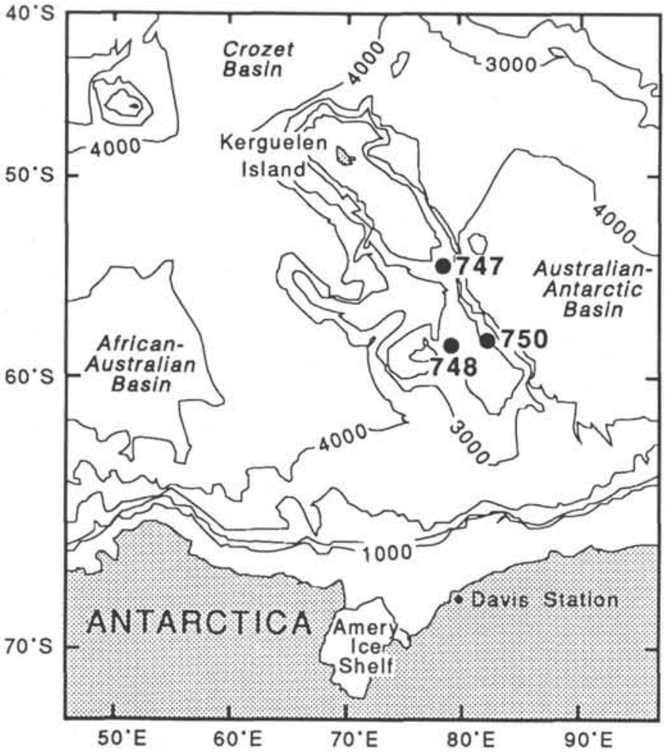

Figure 1. Locations of Sites 747, 748, and 750 drilled during Leg 120. Bathymetry in meters.

BIOSTRATIGRAPHY AND PALEOENVIRONMENTAL RECONSTRUCTION

Albian

Following the initial edifice-building events on the Central Kerguelen Plateau, an island or series of islands emerged from the waters of the Southern Ocean. Weathering products from the basaltic islands in the vicinity of Site 750 began to accumulate as fluvial sediments. Mohr and Gee (Chapter 17, this volume) established the biostratigraphic framework for the basal sediments (Cores 120-750B-12W through -14W) from this site using terrestrial palynomorphs (Fig. 2). Their work indicates an early Albian age for the lower part of the sequence (Section 120-750B-13W-2 through Core 120-750B-14R) and an early middle Albian age for the upper part of the sequence (Core 120-750B-12W through Section 120-750B-13W-1).

Examination of the palynomorph (Mohr and Gee, Chapter 17, this volume) and macrofloral remains (Francis and Coffin, this volume) has yielded a detailed picture of floral colonization and succession on the volcanic islands of the early Kerguelen Plateau. The lowest samples are dominated by sporomorphs with probable affinities to the gleicheniaceaen and dicksoniaceaen pteridophytes. Assuming that the Albian forms had similar ecological niches to the modern forms, these ferns would have been the initial colonizers of the nutrient-poor soils developed on the exposed basalt. The gleicheniaceaens probably would have formed thickets over much of the barren landscape of the newly formed islands. The dicksoniaceaens, by analogy with extant forms, were probably short, stout tree ferns that would have formed a low and probably incomplete canopy over the gleicheniaceaen ground cover. Cycads and rare conifers completed this early colonizer assemblage.

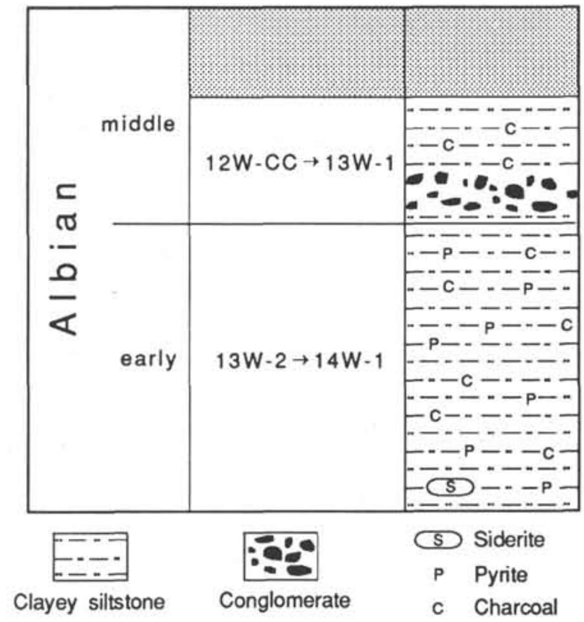

Figure 2. Age relationships of Albian terrestrial sediments from Site 750 (Raggatt Basin) based on the palynomorph ages of Mohr and Gee (this volume). The shaded area indicates a hiatus.

Stratigraphically higher samples illustrate the successional change of the assemblage. Charcoalified podocarp wood and podocarpaceaen sporomorphs become abundant in the sediment of Cores 120-750B-12W and -13W, indicating their increasing importance in the Kerguelen communities. Podocarps eventually became the dominant plants, probably forming a canopy that covered almost all of the forest floor. Other conifers (cupressaceaens and cheirolepidaceaens) and angiosperms composed a minor part of the communities. Based on modern analogs, this canopy may have been over 30 m high. The understory probably consisted of smaller podocarps, tree ferns, and seed ferns (pteridospermophytes). The forest floor was populated by diverse assemblages of ferns. Analogy with modern podocarp-dominated forests suggests that a mild, wet climate existed on the Central Kerguelen Plateau islands during the mid-Albian. The large amount of charcoalified podocarp wood in the sediments indicates that forest fires were fairly frequent in the Kerguelen forest. Although lightning may have started some of these fires, the volcanic nature of Kerguelen suggests that some of these fires may have been the result of subaerial eruptions (Francis and Coffin, this volume).

The podocarp-dominated forests of the mid-Cretaceous Kerguelen islands probably were similar to those of other southern Gondwanan areas, particularly those from the Antarctic Peninsula and southern Australia (Francis, 1986; Francis and Coffin, this volume).

Cenomanian to Santonian

Two markedly different facies of the Cenomanian to Santonian were recovered during Leg 120 drilling: noncalcareous, glauconitic clastic rocks at Site 748 and pelagic carbonate rocks at Sites 747 and 750. The former were dated by means of palynomorphs, the latter largely by calcareous nannofossils. Because these two sections cannot be related directly by first-order correlation, they are discussed separately below.

Noncalcareous Facies of Site 748

The base of the sedimentary section at Site 748 consists of a basalt cobble conglomerate (lithologic Subunit IIIc of

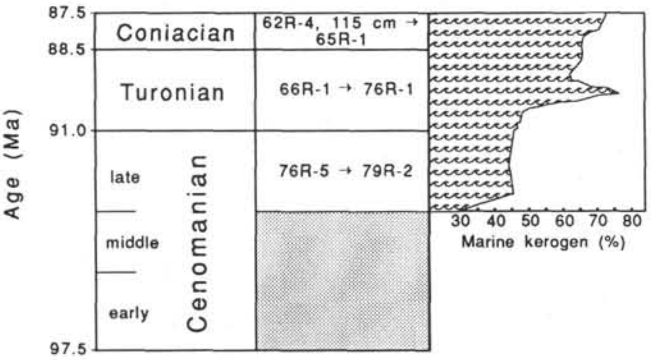

Figure 3. Age relationships of noncalcareous marine sediments at Site 748 (Raggatt Basin) based on palynomorph ages of Mohr and Gee (this volume). The shaded area indicates a hiatus. The marine kerogen percentages (shaded with waves) are from five-member smoothing of the data from Mohr and Gee (this volume). Note the distinct peak in marine kerogen content during the Turonian.

Schlich, Wise, et al., 1989) composed of rounded, altered basalt cobbles and boulders, broken molluscan shells, and a matrix of glauconitic siltstone cemented by sparry calcite. No age-diagnostic fossils were recovered from this thin (1.2 m) horizon.

The interval above this thin basal conglomerate consists of a thick (approximately 188 m) sequence of glauconitic sandstones, siltstones, and claystones that are devoid of calcareous microfossils. Palynological investigation by Mohr and Gee (Chapter 19, this volume) indicates that these sediments contain diverse assemblages of marine dinoflagellate cysts as well as terrestrially derived pollen and spores. Biostratigraphic analyses of the palynomorph assemblages allows subdivision of this interval into three stages (Fig. 3). The sediments in Section 120-748C-76R-5 through Core 120-748C-79R were placed in the upper Cenomanian, based on the occurrence of various species of the dinocyst genus *Florentinia*. Sections 120-748C-66R-1 through -76R-1 were placed in the Turonian based on the occurrence of *Chatangiella victoriensis* without *Kleithriasphaeridium tubulosum*. The appearance of *K. tubulosum* in the interval from Sections 120-748C-65R-1 through -62R-4 indicates the Coniacian. This assignment is corroborated by occurrences of *Maduradinium pentagonum* throughout most of this interval. No Santonian sediments were identified from Site 748.

A quantitative kerogen analysis, using the ratio between marine (dinocysts, acritarchs, and foraminiferal tapeta) and terrestrial (spores and pollen) kerogen, indicates a general trend toward increasing marine input from the late Cenomanian through the Coniacian (Mohr and Gee, Chapter 19, this volume). Although there is considerable inter-sample variation (table 1 and fig. 4 of Mohr and Gee, Chapter 19, this volume), smoothing of the data (five-member moving average, Fig. 3) suggests that marine input initially increased rapidly from <30% to ~45% (Cores 120-748C-76R to -79R), stabilized at ~45% in Cores 120-748C-73R to -76R, and then gradually increased to ~70% from Cores 120-748C-73R to -62R.

There was a distinct peak in the input of marine kerogen during the Turonian (Cores 120-748C-71R through -73R). This Turonian marine kerogen peak is associated with an interval of distinct cross-bedding (see core photographs in Schlich, Wise, et al., 1989, pp. 513–515) and the presence of most of the few macrofossils found in this subunit. A macrofossil fauna from Sample 120-748C-73R-6, 128–132 cm, contains the pectinid bivalve *Camptonectes* sp., the myoid bivalve ?*Panopea* sp., and the serpulid polychaete *Spirorbula* sp. (Quilty, Chapter 24, this volume). The association of the marine kerogen peak, the cross-bedding, and the (albeit limited) macrofauna suggests that this interval represents a period of increased communication with marine waters in what must have been a restricted, marginally marine, depositional setting.

Calculation of sedimentary rock accumulation rates for the noncalcareous facies is difficult because of the lack of correlation of the dinocyst biostratigraphic scale with the absolute time scale. Preliminary estimates suggest rates of 63 m/m.y. for the Turonian interval and 33 m/m.y. for the Coniacian interval, assuming continuous sedimentation throughout the entire stage. Although this assumption may be valid for the Turonian, it is probably not valid for the Coniacian. Thus, our best estimate for the sedimentary rock accumulation rate for the entire noncalcareous sequence (Cores 120-748C-62R through -79R) is approximately 60 m/m.y.

Calcareous Facies of Sites 747 and 750

Unlike the restricted, marginally marine paleoenvironments that distinguished Site 748 during the Cenomanian to Santonian, sporadic periods of open-ocean, pelagic sedimentation characterized Sites 747 and 750 during this time. The biostratigraphy is based largely on calcareous nannofossils, although some critical information was supplied by planktonic foraminifers and dinoflagellate cysts. All three fossil groups, as well as benthic foraminifers, provide the basis for the paleoenvironmental and paleoceanographic reconstructions.

The oldest calcareous pelagic material recovered from Leg 120 is the subject of some controversy. Chips of dark marlstone and dark plastic calcareous mudstone from the basal portion of Core 120-750B-11W have been analyzed for foraminifers, palynomorphs, and nannofossils. A mixed fauna of planktonic foraminifers was recovered from dark, plastic calcareous muds adhering to the core in Section 120-750B-11W-2 (Quilty, Chapter 22, this volume). Specifically, rare but well-preserved specimens of *Praeglobotruncana delrioensis* and *Concavatotruncana imbricata* of Cenomanian-Turonian age were mixed with younger species, including *Globotruncana linneiana* (Santonian-Maestrichtian) and specimens questionably assigned to *Marginotruncana marginata* and *Marginotruncana pseudolinneiana* (late Turonian to Santonian). In addition, a few poorly preserved specimens referred to *Praeglobotruncana* sp. cf. *P. delrioensis* were recovered from *in situ* marlstone in Section 120-750B-11W-2. One sample in Section 120-750B-11W-CC contains the dinocysts *Canninginopsis colliveri* and *Palaeohystrichophora infusorioides*, indicating a probable age of early to middle Cenomanian (Mohr and Gee, Chapter 19, this volume). This sample, however, also has morphologically diverse forms of the dinocyst genus *Isabelidinium*. Although some of these can be assigned to the Cenomanian species *I. glabrum*, others may belong to *I. belfastense* or the genus *Chatangiella*, implying the presence of younger (Turonian-Coniacian) material. Detailed examination of numerous samples for calcareous nannofossils by Watkins (this volume) yielded consistent ages of mid-Coniacian (upper Zone CC13; Section 120-750B-11W-1 through Sample 120-750B-11W-2, 8–10 cm) and late Turonian to early Coniacian (Zone CC12 to lower Zone CC13; Sample 120-750B-11W-2, 76–78 cm, through Section 120-750B-11W-CC) for this material (Fig. 4). No evidence of pre-Turonian or post-Coniacian nannofossils was revealed by this examination.

We think that this peculiar situation is the result of both reworking and the nature of the coring operations. The cored interval for Core 120-750B-11W was 28.9 m (594.6–623.5

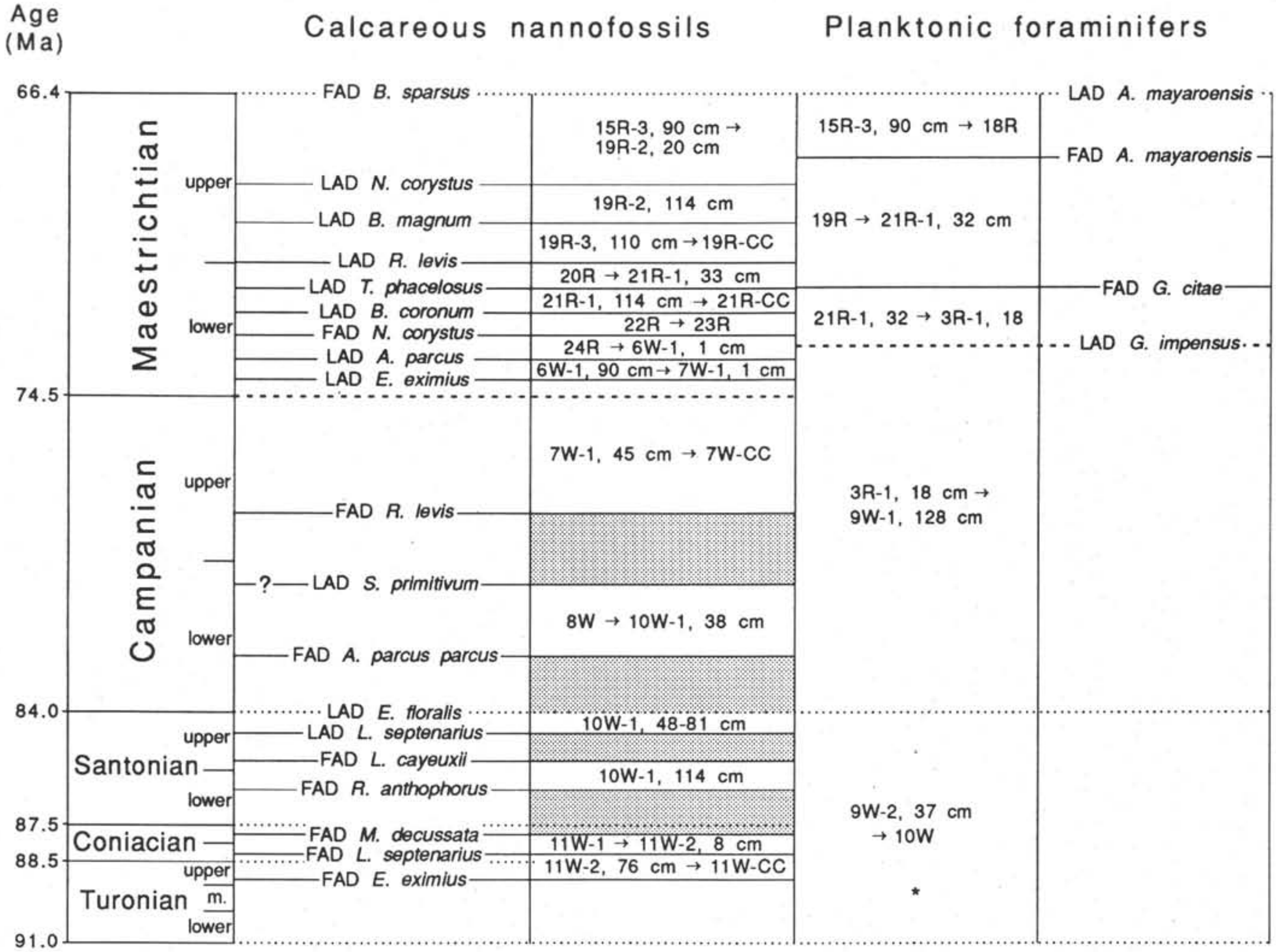

Figure 4. Age assignments of Cretaceous sediments from Site 750 (Raggatt Basin). Shaded areas indicate hiatuses. Note the apparent discordance of the Campanian/Maestrichtian boundaries (heavy broken lines) based on nannofossils and planktonic foraminifers. FAD = first appearance datum and LAD = last appearance datum. For items marked with an asterisk (*), see text and Quilty (Chapter 22, this volume) for a discussion of planktonic foraminifers in Core 120-750B-11W.

mbsf), although only about 3 m was recovered. Thus, approximately 90% of the cored interval was washed out of the barrel. The simplest explanation, therefore, is that the recovered interval (upper Turonian–lower Coniacian) was underlain by Cenomanian pelagic or hemipelagic sediment. During the deposition of the upper Turonian to lower Coniacian chalk and dark marl (recovered in part), some of the larger Cenomanian microfossils (foraminifers and dinocysts) were reworked into the Turonian-Coniacian. Coring operations washed out the underlying Cenomanian but recovered the upper Turonian–lower Coniacian sediment with its reworked Cenomanian microfossils. In addition, some sediment containing stratigraphically higher microfossils (including *Globotruncana linneiana*) was washed downward and forcibly stuck onto the core barrel. The reworking and (in the case of the foraminifers) the downhole contamination was detected during the foraminiferal and palynological examinations because of the large sample sizes used, whereas the minute sample sizes of the nannofossil preparations completely missed the exotic material and only *in situ* upper Turonian–lower Coniacian microfossils were observed.

A thin unit of upper Turonian to lower Coniacian calcareous sediment (correlative to that at Site 750, discussed above) was recovered at Site 747 (Fig. 5). The upper Turonian–lower Coniacian at Site 747 consists of fragments of glauconitic bioclastic packstones with abundant, moderately preserved nannofossils and foraminifers in Section 120-747C-10R-CC. The nannofossil assemblages indicate the upper Turonian–lower Coniacian Subzones CC12–CC13a (Watkins, this volume). Planktonic foraminifers from Section 120-747C-10R-CC include *Concavatotruncana canaliculata, C. algeriana,* and *C. imbricata,* indicating an age that is consistent with that of the nannofossils (Quilty, Chapter 22, this volume). The presence of the calcareous nannofossil *Thiersteinia ecclesiastica* suggests austral affinities for this interval (Watkins, this volume), although the planktonic foraminifer assemblage is regarded as Transitional (Quilty, Chapter 22, this volume). Benthic foraminifers from this interval are dominated by *Gavelinella eriksdalensis,* suggesting deposition in the upper mid-bathyal region, although poor preservation makes interpretation difficult (Quilty, Chapter 23, this volume).

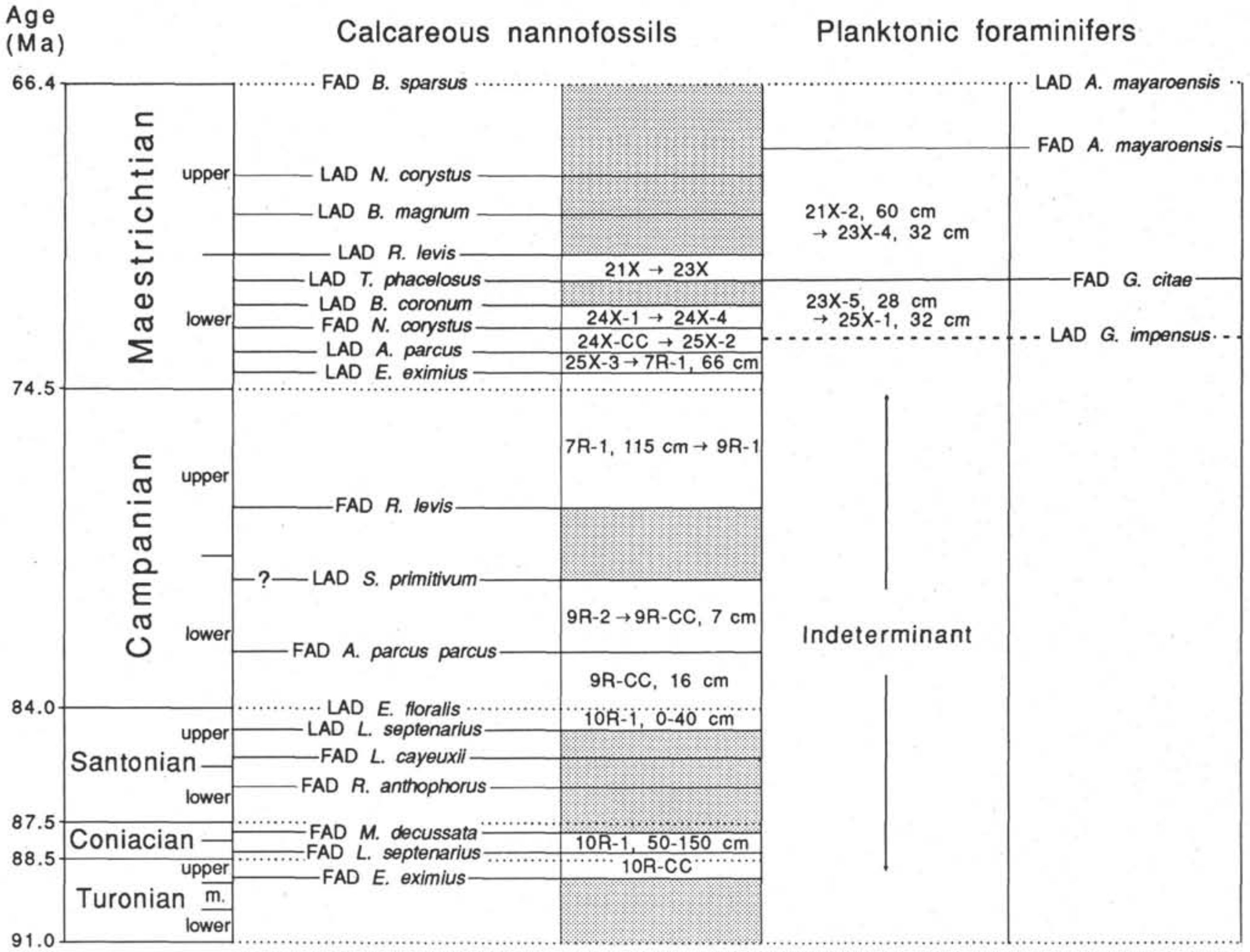

Figure 5. Age assignments of Cretaceous sediments from Site 747. The shaded areas indicate hiatuses. FAD = first appearance datum and LAD = last appearance datum.

Thin units of lower Coniacian chalk occur at Sites 747 and 750 (Figs. 4–5). Calcareous nannofossils at both sites precisely constrain the ages of these units as correlative to Subzone CC13b (Watkins, this volume). Common *Thiersteinia ecclesiastica* suggest austral affinities for these intervals. At Site 747, this interval is represent by only a few *in situ* pieces of chalk in the interval from 120-747C-10R-1, 50–150 cm. At Site 750, this subzone occurs within a similarly thin interval (Section 120-750B-11W-1 through Sample 120-750B-11W-2, 8–10 cm). No foraminiferal samples were examined from either of these intervals.

Sample 120-750B-10W-1, 114–115 cm, at Site 750 (Fig. 4) yielded a mid-Santonian age correlative to nannofossil Zone CC15 (Watkins, this volume). The coring technique (wash coring) and the broken nature of the recovered material (Schlich, Wise, et al., 1989, p. 595) make it impossible to estimate the actual thickness of this unit. This biostratigraphic interval was not observed at Site 747, although this may be an artifact of incomplete core recovery.

Uppermost Santonian chalk was recovered from Sites 747 and 750 (Figs. 4–5). Calcareous nannofossil assemblages from these samples indicate nannofossil Zone CC16. The presence of the planktonic foraminifer *Archaeoglobigerina bosquensis* in this interval at Site 750 is consistent with the Santonian age assignment. This interval is represented by only 40 cm at Site 747 (Interval 120-747C-10R, 0–40 cm) and only 33 cm at Site 750 (Interval 120-750B-10W-1, 48–81 cm). In both cases, however, poor core recovery suggests that this is not the full extent of these units.

Lower Campanian

Lower Campanian calcareous sediments were recovered from Sites 747, 748, and 750. Those at Sites 747 and 750 are pelagic chalks with abundant calcareous microfossils, whereas the lower Campanian at Site 748 consists of calcareous, glauconitic biogenic limestones with a variable, but generally low, content of calcareous microfossils.

The lower Campanian at Site 747 consists of approximately 35 cm of chalk that represents two biostratigraphic zones (Fig. 5). Most of this interval (Section 120-747C-9R-2 through Sample 120-747C-9R-CC, 7–8 cm) contains both *Aspidolithus parcus parcus* and *Seribiscutum primitivum*, placing it in the mid-lower Campanian. The remainder of the interval (120-747C-9R-CC, 9–18 cm) lacks *A. parcus parcus*, indicating the lower lower Campanian. The presence of *S. primitivum* throughout the lower Campanian at this site indicates austral affinities (Watkins, this volume). No planktonic foraminiferal or palynological samples were examined from this interval.

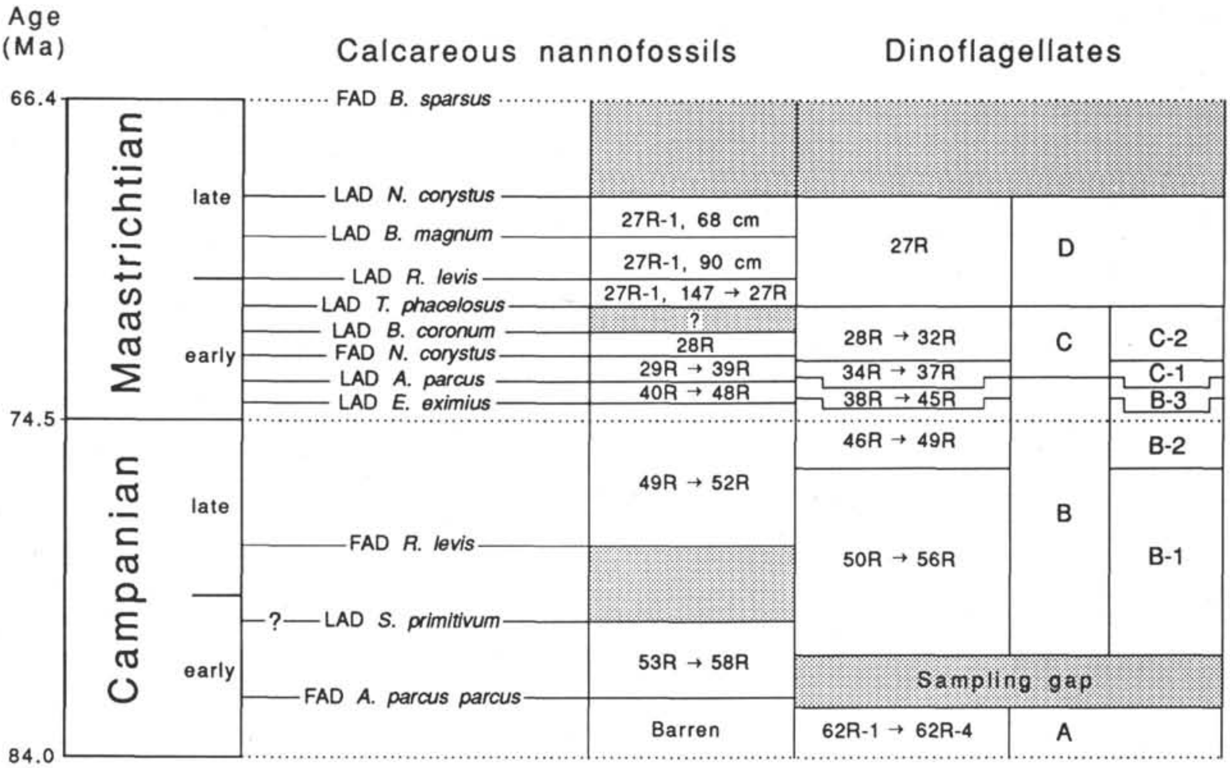

Figure 6. Age assignments of Cretaceous calcareous sediments (Campanian and Maestrichtian) from Site 748 (Raggatt Basin). Shaded areas, unless labeled otherwise, indicate hiatuses. FAD = first appearance datum and LAD = last appearance datum.

The lower Campanian is significantly thicker (at least 22 m) at Site 750 than at Site 747, although the wash coring strategy used makes it impossible to estimate the thickness precisely. The presence of both *A. parcus parcus* and *S. primitivum* in this interval (Core 120-750B-8W through Sample 120-750B-10W-1, 38–39 cm) indicates the mid-lower Campanian (Fig. 4; Watkins, this volume). In general, the poor character of the foraminifer assemblages from this interval makes precise age determinations impossible, although the taxa present are consistent with the nannofossil-based age assignment. The benthic foraminifer assemblages within this interval are sparse, poorly preserved, and of little paleoecologic value (Quilty, Chapter 23, this volume).

Biostratigraphic characterization of the lower Campanian at Site 748 (Fig. 6) is complicated because of poor core recovery, intervals of noncalcareous sediment, sampling gaps, and the lack of a well-calibrated dinocyst biostratigraphy for this part of the geologic column. We assigned the interval from Core 120-748C-53R through Sample 120-748C-62R-4, 98–101 cm, to the lower Campanian. Calcareous nannofossil biostratigraphy indicates that the interval from Cores 120-748C-53R through -58R is mid-lower Campanian based on the mutual occurrence of *Aspidolithus parcus parcus* and *Seribiscutum primitivum* (Fig. 6). This interval comprises part of dinocyst Subzone B-1 of Mao and Mohr (this volume). No planktonic foraminifers were recovered from this interval. Cores 120-748C-59R and -60R contain only small silicified fragments of clayey glauconitic sandstone that are barren of nannofossils. The underlying sequence in question (Cores 120-748C-61R and -62R) is noncalcareous. No palynological samples were examined from Cores 120-748C-59R through -61R, creating a sampling gap (Fig. 6). Dinocysts from Section 120-748C-62R-1 through Sample 120-748C-62R-4, 98–101 cm, have been assigned to dinocyst Zone A of Mao and Mohr (this volume; see Fig. 6), which was assigned tentatively to the lowest Campanian.

There are significant differences between the upper (Cores 120-748C-53R through -56R) and lower (Section 120-748C-62R-1 through Sample 120-748C-62R-4, 101 cm) parts of this lower Campanian section. These two parts are separated by an interval (Cores 120-748C-57R through -61R) of almost no core recovery. The upper part contains a fairly diverse assemblage of calcareous nannofossils, dinocysts, and calcareous benthic foraminifers as well as rare hedbergellid and globigerinelloidid planktonic foraminifers. The lower interval contains only depauperate assemblages of dinocysts and rare agglutinated benthic foraminifers (genus *Saccammina*). It seems clear that the lower interval (= Zone A of Mao and Mohr, this volume) was deposited in a marginally marine environment with little or no connection to open-ocean, surface-water masses, whereas the upper part of the section was deposited under fully oceanic conditions. Unfortunately, the nature of this transition is impossible to ascertain given the very poor core recovery in the transitional zone.

Mid-Campanian Disconformity

All three Leg 120 sites that penetrated the Cretaceous recorded the presence of a mid-Campanian disconformity (Figs. 4–6). Watkins et al. (1989) noted the occurrence of this disconformity on both the Kerguelen (Leg 120) and Falkland (Deep Sea Drilling Project Legs 36 and 71) plateaus. This disconformity is also present on the Northeast Georgia Rise (ODP Leg 114; Crux, 1991). The evidence presently available suggests that this disconformity is ubiquitous throughout the Atlantic and Indian sectors of the Southern Ocean. Watkins (this volume) suggests that this disconformity is the demarcation between the weakly endemic nannofloras of the Turonian through lower Campanian and the highly endemic (austral) nannofloras of the upper Campanian through Maestrichtian.

Late Campanian–Maestrichtian

Site 747 contains approximately 92.5 m of upper Campanian and lower Maestrichtian chalk topped by volcaniclastic debris flows (Fig. 5). The presence of numerous austral calcareous nannofossil species (such as *Nephrolithus corystus, Biscutum magnum, Biscutum coronum, Monomarginatus* spp., and *Misceomarginatus pleniporus*) and the absence of temperate taxa (such as *Quadrum trifidum, Q. gothicum,* and *Ceratolithoides aculeus*) indicate that this area was distinctly austral during the late Campanian and early Maestrichtian. The planktonic foraminifer assemblages from this interval are dominated by *Heterohelix, Hedbergella, Globigerinelloides,* and/or *Archaeoglobigerina*. Keeled globotruncanids are present but rare, also indicating cool, austral, near-surface water conditions. The foraminifer assemblages are dominated by planktonic forms, except in the interval from 220 to 235 mbsf (approximately equal to Cores 120-747A-24X through -25X), where denser benthic specimens are concentrated. Quilty (Chapter 22, this volume) attributes this concentration of dense benthic forms to sediment winnowing by bottom-current activity. The benthic foraminifer assemblages are dominated by *Stensioeina beccariiformis*. In general, the benthic foraminifer assemblages indicate a gradual subsidence from the lower mid-bathyal (late Campanian) to the upper lower bathyal (early Maestrichtian), with the plateau subsiding below the 1000 m isobath at approximately the Campanian/Maestrichtian boundary (Quilty, Chapter 23, this volume).

The upper Campanian and Maestrichtian of Site 748 consists of a 246-m-thick sequence of glauconitic, biogenic rudstones, grainstones, packstones, and wackestones containing varying proportions of neritic and pelagic fossil material. The majority of the calcareous biogenic fossil material is derived from bryozoans and inoceramids, with lesser contributions by benthic foraminifers, echinoids, crinoids, and sponge spicules. Rare coralline red algae (see "Frontispiece," this volume) occur in Core 120-748C-32R, indicating deposition near the top of the photic zone. The pelagic microfossil component is minor, although there are sufficient calcareous nannofossils present for age determinations. Dinocysts are common to abundant in the acid-insoluble fine fraction of this sediment. Their occurrence with the calcareous nannofossils affords an opportunity for calibration of the biostratigraphic sequences of these two microfossil groups (Fig. 6). Calcareous nannofossil biostratigraphy indicates that most of the upper Campanian and Maestrichtian are present with the exception of the uppermost Maestrichtian. Another possible disconformity of relatively short hiatus may be present within the upper Maestrichtian (Fig. 6), although this may be an artifact of poor core recovery.

The foraminifer assemblages are dominated strongly by benthic specimens, with planktonic forms often <50% of the total assemblage. The planktonic taxa consist of long-ranging forms with little or no age-diagnostic value. The benthic foraminifer assemblages are dominated by *Gavelinella sandidgei* and *Alabamina australis,* indicating deposition in waters that were probably <20 m in depth (Quilty, Chapter 23, this volume). In particular, one interval (Core 120-748C-31R through -35R; 445.0–492.5 mbsf) seems to have been deposited in very shallow water: the coarse to very coarse nature of the grainstones, the presence of rounded grains, the strong dominance of the benthic foraminifer assemblages by *Alabamina australis,* the absence of planktonic foraminifers and calcareous nannofossils, the dominance of dinocyst assemblages by cavate (peridinioid) cysts, and the presence of coralline red algae all indicate deposition in very shallow marine waters.

Site 750 contains the most complete upper Campanian through upper Maestrichtian section of any thus far recovered from the Southern Ocean. Approximately 177.3 m of nannofossil chalk containing abundant, generally well-preserved assemblages of calcareous nannofossils and foraminifers was recovered from this site. Watkins (this volume) divided this sequence into nine biostratigraphic units based on first and last occurrences of nannofossils. Five of these nannofossil taxa are cosmopolitan, whereas four are largely austral in distribution. Quilty (Chapter 22, this volume) divided this interval into three biostratigraphic zones based on the stratigraphic distribution of *Abathomphalus mayaroensis, Globotruncanella citae,* and *Globinerinelloides impensus* (Fig. 4). The Campanian/Maestrichtian boundary is placed within Section 120-750B-7W-1 based on nannofossils and within Section 120-750B-3R-1 based on planktonic foraminifers (compare placement of broken lines in Fig. 4). This apparent inconsistency is almost certainly a result of the inaccuracies of the stage calibrations for these two fossil groups.

The upper Campanian through lower Maestrichtian nannofossil and planktonic foraminifer assemblages are very similar to coeval assemblages at Site 747, indicating strongly austral conditions. The paleobiogeographic affinities of the upper Maestrichtian calcareous microplankton assemblages are not totally consistent. The upper Maestrichtian nannofossil assemblages contain numerous austral taxa such as *Nephrolithus corystus, Biscutum magnum, Cribrosphaerella daniae,* and *Misceomarginatus pleniporus* but lack such temperate species as *Micula murus* and *Lithraphidites quadratus. Watznaueria barnesae* is absent throughout the entire upper Maestrichtian. The uppermost Maestrichtian contains abundant *Prediscosphaera stoveri.* These species associations all indicate that austral conditions prevailed throughout the end of the Cretaceous (Watkins, this volume). The planktonic foraminifer assemblages, however, suggest that the late Maestrichtian was warmer or less distinctly austral than the late Campanian and early Maestrichtian. The presence of *Pseudotextularia deformis, Heterohelix semicostata,* and several species of *Globotruncana, Gublerina,* and *Racemiguembelina* suggest that these assemblages were deposited within the warmer parts of the Transitional Faunal Province (Quilty, Chapter 22, this volume). This is especially true of the very diverse assemblages of the uppermost Maestrichtian.

Huber (1990) noted a similar influx of "Transitional Faunal Province" planktonic foraminifers in the upper Maestrichtian of Maud Rise (ODP Sites 689 and 690). Upper Maestrichtian calcareous nannofossil assemblages from Maud Rise (Pospichal and Wise, 1990), like their counterparts from the Central Kerguelen Plateau, were strictly austral in character, with no evidence of increasing surface-water temperatures. Oxygen isotope analyses of the upper Maestrichtian planktonic foraminifers from Maud Rise (Barrera and Huber, 1990) and the Antarctic Peninsula (Barrera et al., 1987) indicated a continued cooling in surface-water temperatures through the late Maestrichtian. Based on this evidence, it is likely that paleoceanographic factors other than temperature are responsible for the influx of "Transitional" planktonic foraminifers into the late Maestrichtian Southern Ocean (Huber, 1990).

The upper Campanian through Maestrichtian benthic foraminifer assemblages from Site 750 are dominated by *Stensioe-*

ina beccariiformis and species of *Gyroidinoides, Praebulimina,* and *Gavelinella,* suggesting middle to upper bathyal water depths (Quilty, Chapter 23, this volume).

SUMMARY AND CONCLUSIONS

Volcanic islands appeared during the late stages (early Albian) of edifice building of the Kerguelen Plateau. Although initially barren, these islands soon were colonized by low, creeping ferns and tree ferns during the early Albian. As more plants were introduced to the islands (probably as spores and seeds), the opportunistic colonizers were gradually succeeded by a podocarp-dominated coniferous forest with a diverse fern and tree fern understory complex. This podocarp-fern climax forest was well established by the middle Albian. Forest fires, ignited by lightning or volcanic eruption, generated abundant charcoal, which was deposited in nearby fluvial environments.

Foundering of the Central Kerguelen Plateau was uneven, as each of the three Cretaceous sections records a different sedimentary (Fig. 7) and subsidence history. The eastern edge of the Central Kerguelen Plateau (Site 750) foundered sometime during the late Albian and early Cenomanian. The middle Albian podocarp-pteridophyte forest complex gave way to pelagic chalk/marl deposition at middle-lower neritic depths by the early to middle Cenomanian. Poor core recovery prohibits reconstruction of most of the middle Cenomanian–Turonian history of this area, although it is evident that this area had subsided to lower neritic to upper bathyal depths by the late Turonian–early Coniacian. The western part of the Central Kerguelen Plateau (Site 748) did not begin to accumulate marine sediments until the late Cenomanian. These sediments apparently accumulated in a restricted, inner-neritic environment throughout the late Cenomanian, Turonian, and early(?) Coniacian. Accumulation of marine sediment in the northern part of the Central Kerguelen Plateau (Site 747) did not commence until the late Turonian–early Coniacian. This part of the central plateau had already subsided to upper mid-bathyal depths by this time, however, so its early subsidence history is not represented in the rock record at Site 747. Thus, by the late Turonian–early Coniacian, the northern and eastern parts of the Central Kerguelen Plateau had subsided to upper mid-bathyal and upper bathyal depths (respectively), whereas the westernpart of the central plateau was shallow (inner neritic) and restricted.

The late Coniacian and early Santonian history of the Central Kerguelen Plateau is apparently represented only by disconformities, although the poor core recovery at Site 750 makes this uncertain. The late Santonian and early Campanian are represented by only thin sedimentary units bounded by disconformities at all three sites (Fig. 7). This suggests sporadic sedimentation over the Central Kerguelen Plateau, although the wash-coring strategy at Site 750 makes this interpretation uncertain. Both the eastern and northern parts of the central plateau experienced spurts of pelagic calcareous sedimentation during this time, with the eastern margin accumulating a greater thickness of chalk. Depth estimates are less constrained than for other times, although it is most likely that these sites were at lower mid-bathyal (Site 747) and upper bathyal (Site 750) depths during the late Santonian–early Campanian. The western part of the Central Kerguelen Plateau (Site 748) was still shallow (mid-neritic) during the early Campanian, although communication with ocean-water masses was open enough to allow invasion of calcareous oceanic microplankton into the area. Deposition of a bryozoan-molluscan-foraminifer (benthic) bank complex and associated facies began in the western part of the central plateau during the early Campanian.

Sediment accumulation halted all over the central plateau during the mid-Campanian (Fig. 7). This disconformity event (or events) appears to be the result of large-scale oceanographic events in the Southern Ocean, as opposed to causes localized on the Kerguelen Plateau. It appears that events occurring during this hiatus led to the ecological separation of Southern Ocean nannoplankton communities from those of the temperate regions, as endemism within the Southern Ocean nannoplankton realm was much greater during the late Campanian and (especially) Maestrichtian than in previous times.

Pelagic calcareous sedimentation resumed in the northern and eastern parts of the Central Kerguelen Plateau during the late Campanian. Chalk sedimentation continued throughout the Maestrichtian on the eastern margin of the central plateau. Highly austral assemblages of calcareous nannoplankton and planktonic foraminifers characterized the surface and near-surface water masses in this area. Subsidence appears to have been gradual and slow, with the area sinking to mid-upper bathyal depths by the end of the Maestrichtian. Planktonic foraminifer assemblages suggest that some degree of warming may have occurred during the latest Maestrichtian, although this is not reflected in the nannofossil assemblages. In the northern part of the central plateau (Site 747), pelagic carbonate sedimentation was abruptly curtailed near the end of the early Maestrichtian by the introduction of volcaniclastic debris flows. Evidence suggests that this region of the plateau experienced accelerated subsidence during the late Campanian–early Maestrichtian, passing through the lower mid-bathyal (Campanian) into the upper lower bathyal by the early Maestrichtian. Bryozoan-molluscan-foraminifer bank and bank-related facies accumulated on the western part of the central plateau during this time. Water depths remained in the inner-middle neritic throughout this time, with one protracted episode of very shallow bank deposition during the early Maestrichtian. Bank and bank-related deposition appears to have ceased during the early late Maestrichtian (based on the record at Site 748), although it may have continued until the end of the Maestrichtian at other sites in this area.

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APPENDIX

Microfossils Considered in this Report in Alphabetical Order of Generic Epithets

Complete references to individual taxa are in Watkins (calcareous nannofossils; Chapter 21, this volume), Quilty (planktonic and benthic foraminifers; Chapters 22 and 23, this volume), Mohr and Gee (Cenomanian-Coniacian dinoflagellates; Chapters 17 and 19, this volume), and Mao and Mohr (Campanian-Maestrichtian dinoflagellate cysts; Chapter 20, this volume).

Calcareous Nannofossils

Aspidolithus parcus parcus (Stradner, 1963) Noël (1969)
Biscutum coronum Wind and Wise *in* Wise and Wind (1977)
Biscutum magnum Wind and Wise *in* Wise and Wind (1977)
Ceratolithoides aculeus (Stradner, 1961) Prins and Sissingh *in* Sissingh (1977)
Cribrosphaerella daniae Perch-Nielsen (1973)
Lithraphidites quadratus Bramlette and Martini (1964)
Lucianorhabdus cayeuxii Deflandre (1959)
Micula murus (Martini, 1961) Bukry (1973)
Misceomarginatus pleniporus Wind and Wise *in* Wise and Wind (1977)
Nephrolithus corystus Wind (1983)
Prediscosphaera stoveri (Perch-Nielsen, 1968) Shafik and Stradner (1971)
Quadrum gothicum (Deflandre, 1959) Prins and Perch-Nielsen *in* Manivit et al. (1977)
Quadrum trifidum (Stradner *in* Stradner and Papp, 1961) Prins and Perch-Nielsen *in* Manivit et al. (1977)
Seribiscutum primitivum (Thierstein, 1974) Filewicz et al. *in* Wise and Wind (1977)
Thiersteinia ecclesiastica Wise and Watkins *in* Wise (1983)
Watznaueria barnesae (Black *in* Black and Barnes, 1959) Perch-Nielsen (1968)

Dinoflagellate Cysts

Canninginopsis colliveri (Cookson and Eisenack, 1960)
Chatangiella victoriensis (Cookson and Manum, 1964) Lentin and Williams (1976)
Isabelidinium belfastense (Cookson and Eisenack, 1962) Lentin and Williams (1977)
Isabelidinium glabrum (Cookson and Eisenack, 1969) Lentin and Williams (1977)
Kleithriasphaeridium tubulosum (Cookson and Eisenack, 1969) Stover and Evitt (1978)
Maduradinium pentagonum (Cookson and Eisenack, 1970)
Palaeohystrichophora infusorioides Deflandre (1935)

Foraminifers

Abathomphalus mayaroensis (Bolli, 1951)
Alabamina australis Belford (1960)
Archaeoglobigerina bosquensis Pessagno (1967)
Concavatotruncana algeriana (Caron, 1966)
Concavatotruncana canaliculata (Reuss, 1854)
Concavatotruncana imbricata (Mornod, 1950)
Gavelinella sandidgei (Brotzen, 1936) Sliter (1968)
Globinerinelloides impensus Sliter (1977)
Globotruncana citae Bolli (1951)
Globotruncana linneiana (d'Orbigny, 1839)
Heterohelix semicostata (Cushman, 1938)
Marginotruncana marginata (Reuss, 1845)
Marginotruncana pseudolinneiana (Pessagno, 1967)
Praeglobotruncana delrioensis (Plummer, 1931)
Pseudotextularia deformis (Kikoine, 1948)
Stensioeina beccariiformis (White, 1928)

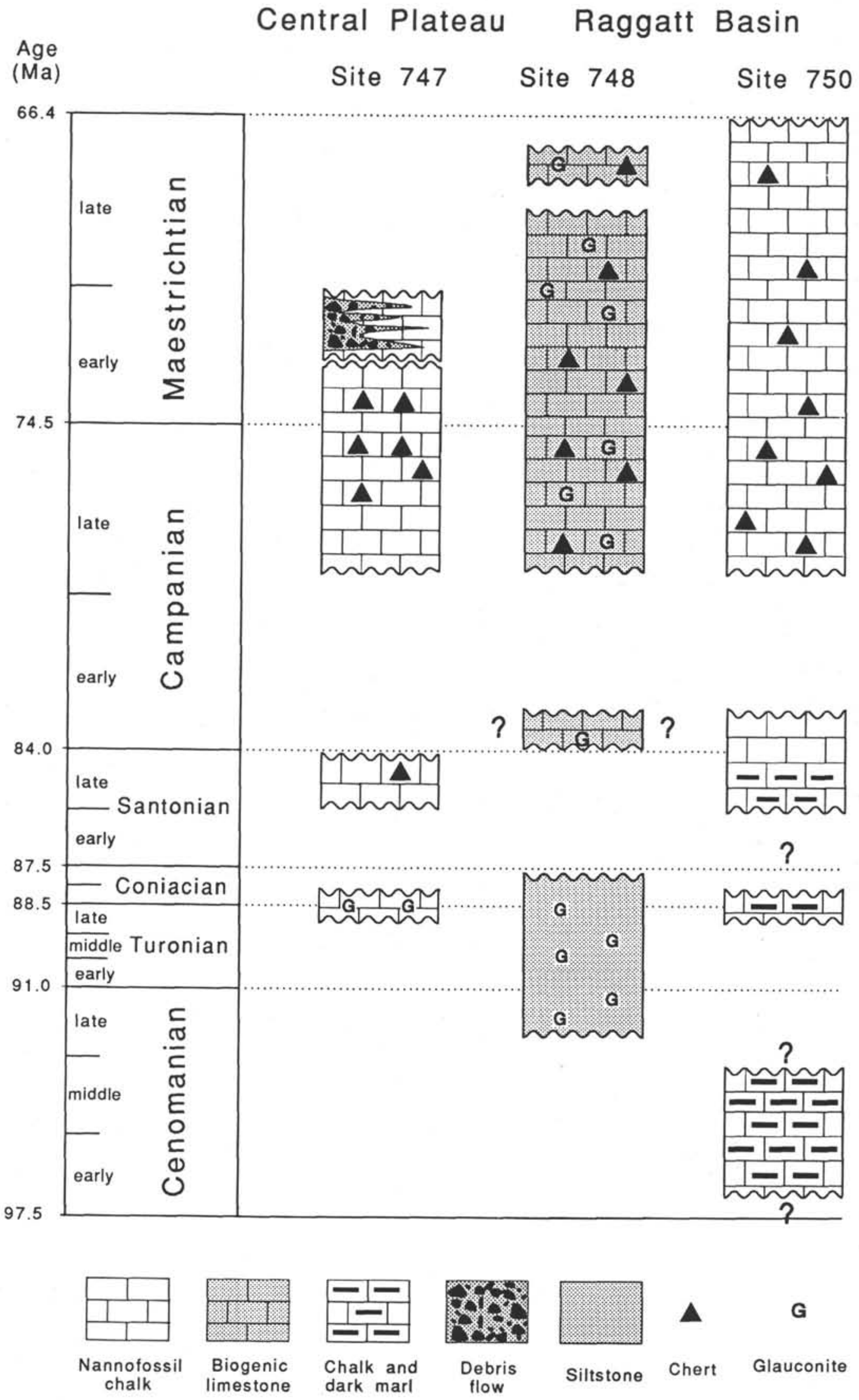

Figure 7. Distribution of Upper Cretaceous lithologies in geologic time (Leg 120). Note that the vertical dimension of a sediment unit in this plot is representative of its duration, not of its actual thickness.