29. CORRELATION OF CARNIAN TO RHAETIAN PALYNOLOGICAL, FORAMINIFERAL, CALCAREOUS NANNOFOSSIL, AND OSTRACODE BIOSTRATIGRAPHY, WOMBAT PLATEAU[1]

W. Brenner,[2] P. R. Bown,[3] T. J. Bralower,[4] S. Crasquin-Soleau,[5] F. Dèpêche,[5] T. Dumont,[6] R. Martini,[7] W. G. Siesser,[8] and L. Zaninetti[7]

ABSTRACT

During Ocean Drilling Program Leg 122, Upper Triassic sediments were recovered at four sites (Sites 759, 760, 761, and 764) on the Wombat Plateau, a small horst on the northern margin of the Exmouth Plateau. Biostratigraphic results vary at each site, because of environment changes from prodeltaic in the late Carnian to marginal-marine and fluvial nonmarine in the Norian, and finally to reefal and mudflat in the Rhaetian. Sediments from these sites have been examined for calcareous nannofossils, dinoflagellates, foraminifers, ostracodes, radiolarians, and spores and pollen.

The biostratigraphy of the Carnian-Norian sequence is based primarily on organic microfossils, since the rare occurrence of calcareous microfossils minimizes the stratigraphic potential of those groups. The carbonates of the overlying Rhaetian sequence, however, contain rich foraminifers, ostracodes, and calcareous nannofossil assemblages. Siliceous microfossils in the Carnian to Rhaetian sequence are nearly absent, except for rare fragments of radiolarians.

The near-continuous late Carnian to Rhaetian sequence recovered on the Wombat Plateau allows us to compile a biostratigraphic framework for different fossil groups.

INTRODUCTION

During the course of Leg 122, a north-south transect of nine holes at four sites was drilled on the Wombat Plateau of northwestern Australia (Fig. 1). The unexpected discovery of marine sediments of Carnian-Rhaetian age presented the opportunity to develop an integrated biostratigraphic scheme for the area based on multiple microfossil groups.

The oldest sediments recovered at the Wombat Plateau are late Carnian in age and constitute the oldest marine sediments obtained by Deep Sea Drilling Project/Ocean Drilling Program (DSDP/ODP) expeditions. The sedimentary succession begins with upper Carnian prodelta claystones and siltstones, and grades into deltaic, marginal-marine and fluvial non-marine sediments in the uppermost Carnian (Hole 759B). The Norian sequence (upper part of Hole 759B, Hole 760A, Hole 760B, and base of Hole 761C) is dominated by marginal marine siliciclastic sediments (silty claystones to silty sandstones) interbedded with fossiliferous limestone. This sedimentary succession indicates a fluctuating shallow-marine (floodplain or lagoonal/intertidal to carbonate bank/shelf) environment. The Rhaetian section (Holes 761C, 764A, and 764B) is dominated by shallow-marine carbonates, including a thick unit of a reef complex at Site 764.

Pre-cruise biostratigraphic data from the Wombat Plateau are available from dredge samples, collected during the R/V *Sonne* cruise 8 (von Stackelberg et al., 1980) and *Rig Seismic* cruise 56 (Schott, pers. comm., 1988). These samples had previously been dated as Early Jurassic, but a reexamination of this material by Quilty (1990), and by Kristan-Tollmann and Gramann (this volume) indicates a Late Triassic rather than Early Jurassic age. This age is also confirmed indirectly by Röhl et al. (this volume) on the basis of microfacies and carbonate diagenesis analysis from Leg 122 material, in comparison with the dredge material of SO-8 and RS-56.

ZONATION PHILOSOPHY AND AGE CONTROL

Australian Late Triassic marine faunas and floras have been only infrequently reported, foraminifers have been studied by Apthorpe and Heath (1981), dinoflagellates by Helby et al. (1987) and Stover and Helby (1987), and conodonts have been studied by Jones and Nicoll (1985). Plant microfossils, however, have been more extensively described (e.g., De Jersey, 1975; De Jersey and McKellar, 1981; Dolby and Balme, 1976; Helby et al., 1987).

Magnetostratigraphic studies of the Triassic sediments (Galbrun, this volume, chapter 41) are not useful for chronostratigraphic dating because the magnetic polarity sequence of the Late Triassic is not well known (e.g., Haq et al., 1987) and the Carnian to Rhaetian sequence of the Wombat Plateau shows many more polarity zones than previously established for the Late Triassic (Galbrun, this volume, chapter 41). Other stratigraphic data (e.g., isotopic age determinations of Upper Triassic sediments) are not available.

The absence of geochronologic data and the infrequent and scattered reports of Triassic marine fossils from the Australian Northwest Shelf necessitates the correlation of Triassic material from Leg 122 with well-known assemblages from the northern Tethys. However, this also requires that long-distance correlation, and therefore the possible diachroneity of ranges of species, has to be considered.

Biostratigraphic units for the different marine microfossils and nannofossils consist mainly of range zones, taxon-range

[1] von Rad, U., Haq, B. U., et al., 1992. *Proc. ODP, Sci. Results,* 122: College Station, TX (Ocean Drilling Program).
[2] Department of Paleoceanography, GEOMAR, Wischhofstr. 1-2, D-2300 Kiel, 14, Federal Republic of Germany.
[3] Department of Geological Sciences, University College London, Gower Street, London, WC1E 6BT, United Kingdom.
[4] Department of Geology, University of North Carolina, Chapel Hill, NC 27599-3315, U.S.A.
[5] Université Paris VI, Département de Géologie Sédimentaire, U.R.A. CNRS 1315, 4 place Jussieu, 75252 Paris Cédex 05, France.
[6] University of Grenoble, rue Maurice Gignoux, 98031 Grenoble Cedex, France.
[7] University of Geneva, 13 rue des Maraichers, 12211 Genève 4, Switzerland.
[8] Department of Geology, Vanderbilt University, Nashville, TN 37235, U.S.A.

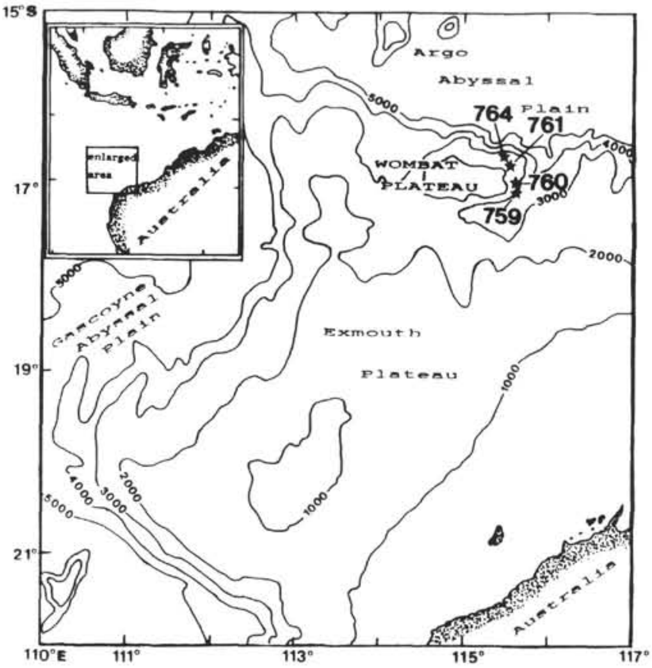

Figure 1. Bathymetric map (in meters) of the northwest Australian shelf region showing the location of Leg 122 sites on the Wombat Plateau.

zones, and concurrent-range zones in the sense of Hedberg (1976); that is, based on the presence or absence of specific species. The presence of any organism at a particular time and place, however, is controlled by a multitude of different factors. Provincialism, different preservation, climatic variation, and local or regional paleoecological factors are the main stumbling blocks for long-distance correlations (e.g., Hallam, 1985; Middlemiss and Rawson, 1971).

Similar problems for age determination and correlation exist for the spore/pollen stratigraphy. The palynostratigraphic units described for the Australian Triassic (Balme, 1964; Dolby and Balme, 1976; Helby et al., 1987) are based on the principle of assemblage zones and Oppel zones (Hedberg, 1976). As is the case with marine fossils, the chronostratigraphy of the palynozones is based on correlation with European floras.

Nevertheless, a combination of different fossil groups with different controlling factors allows us to compile a biochronostratigraphic framework for the Late Triassic of the Wombat Plateau and to analyze potential diachroneity.

SITE SUMMARIES

Site 759

Location: 16°57.24′S, 115°33.63′E; water depth: 2091.6 m.

Hole 759B

Shipboard paleontological studies have been carried out on all fossil groups mentioned above, but only a few foraminifers, ostracodes, and fragments of radiolarians could be found in the Triassic sediments of Hole 759B (Blome, this volume; Haq, von Rad, O'Connell, et al., 1990) (Fig. 2). The sediments from Cores 122-759B-25R through -39R possess numerous intervals rich in possible nannofossils. However, these are sideritic forms, which may represent diagenetic replacement of calcareous nannofossils and have been not studied for this volume (Bralower et al., this volume). Four of 28 samples contain ostracodes and two (from Section 122-759B-11R-2 and -13R-1) give a late Norian to Rhaetian age (Dépêche and Crasquin-Soleau, this volume). Organic microfossils, predominantly spores and pollen, are present in most Triassic samples (Brenner, this volume, chapter 23).

The Upper Triassic sequence of Hole 759B could be subdivided into three palynozones. The lower part (Core 122-759B-20R to the bottom of the hole) corresponds to the *Samaropollenites speciosus* Zone of Dolby and Balme (1976) and is Carnian in age. This interval could be subdivided into five parts on the basis of different palynomorph assemblages (Brenner, this volume, chapter 23) and represents a upward-shallowing prodeltaic to delta-front sequence (Cores 122-759B-27R through -39R) followed by a open marine/intertidal or shallow subtidal to fluviodeltaic interval (Cores 122-759B-20R through -27R).

The overlying sediments indicate a fluviodeltaic to carbonate environment (lower part of Cores 122-759B-6R through -20R). The poor recovery in this interval, in addition to several facies changes that may overprint the fossil record, does not allow a clear biozonation. Nevertheless, the spore/pollen assemblages of this interval have affinities with the *Minutosaccus crenulatus* Zone of Dolby and Balme (1976) which is Norian in age, whereas the absence of the dinoflagellate cyst *Suessia listeri* and the presence of *Shublikodinium* spp. suggests that this interval belongs to the *Shublikodinium wigginsii* Zone of Helby et al. (1987), which is Carnian in age. Conflicting evidence is given by two ostracode samples (Sections 122-759B-11R-2 and 122-759B-13R-1) that indicate a late Norian to Rhaetian age (Dépêche and Crasquin-Soleau, this volume, chapter 23). Therefore, an undifferentiated Carnian to Norian age is assigned to this interval.

The presence of the dinoflagellate cysts *Heibergella balmei* and *Suessia listeri* at the top of the Triassic sequence in the upper part of Core 122-759B-6R indicate the *Heibergella balmei* Zone of Helby et al. (1987), which is late Norian in age.

Site 760

Location: 16°55.32′S, 115°32.48′E; water depth: 1969.7 m.

Hole 760A

The environment of the Triassic interval from Cores 122-760A-11X through -37X varies from shallow-marine to nonmarine (a soil profile and several nonmarine palynomorph assemblages) (Fig. 3). Except for a sideritic nannofossil? assemblage at the base of the hole (Cores 122-760A-35X through -37X) no other calcareous and siliceous microfossils or nannofossils could be found (Haq, von Rad, O'Connell, et al., 1990). The presence of the dinoflagellate cyst *Suessia listeri* in the marine sediments indicate the *Suessia listeri* Zone, which suggests a Norian age for the entire interval (Helby et al., 1987).

Hole 760B

The paleoenvironment of sediments recovered in this hole is similar to those in Hole 760A and to the upper part of the Triassic sequence in Hole 759B. On the basis of palynomorphs Hole 760B can be divided into two palynozones. The dinoflagellate cyst and spore/pollen assemblages of the lower interval from Cores 122-760B-13R through -29R appear to be similar to the interval from Cores 122-759B-6R through -20R of Hole 759B. Therefore, an intermediate spore/pollen zone between the *Samaropollenites speciosus* Zone and the *Minutosaccus crenulatus* Zone of a Carnian to Norian age is proposed for this interval. The presence of the

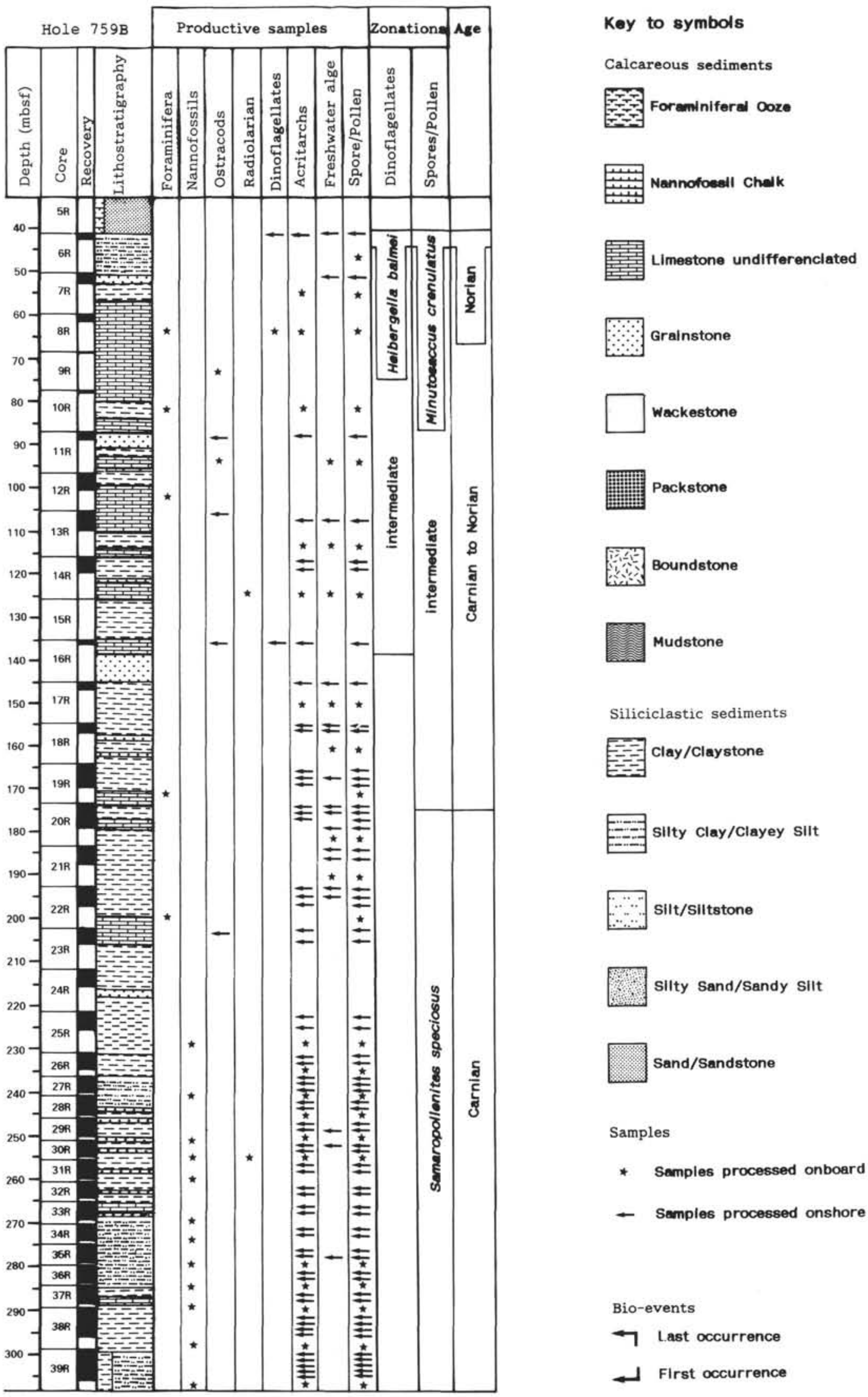

Figure 2. Biostratigraphic zonation of Hole 759B with location of fossiliferous samples.

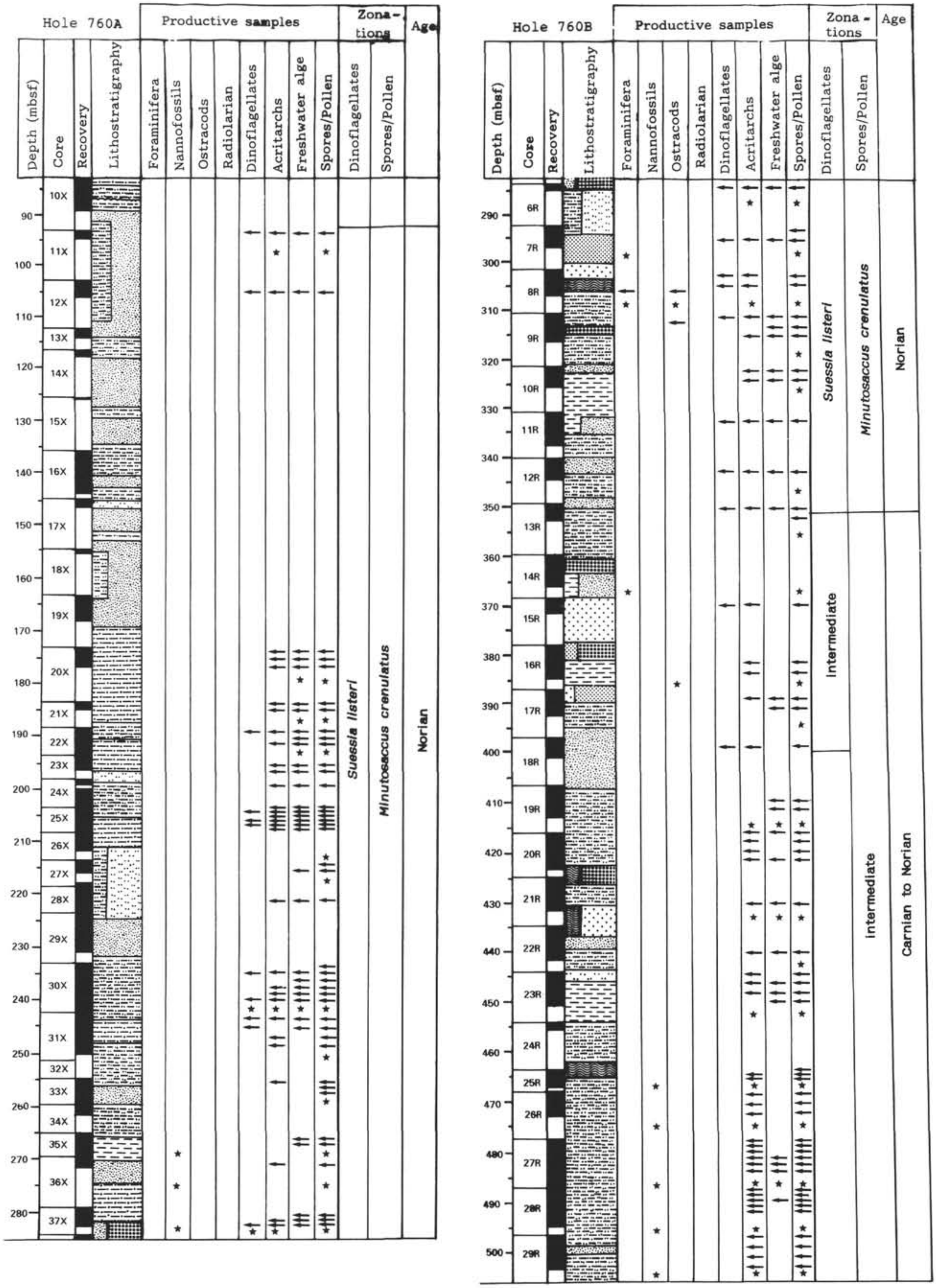

Figure 3. Biostratigraphic zonation of Holes 760A and 760B with location of fossiliferous samples. See Figure 2 for key to symbols.

dinoflagellate cyst *Suessia listeri,* as well as the ostracodes *Ogmoconcha martini* and *Rhombocythere penarthensis,* indicate a Norian age for the interval from Core 122-760B-6R through -12R (Dépêche and Crasquin-Soleau, this volume). Nevertheless, several isolated and well-preserved specimens of the foraminifer *Involutina liassica* in Core 122-760B-8R allow us to consider a younger age (late Norian–Rhaetian) for the upper part of Hole 760B (Zaninetti et al., this volume).

Site 761

Location: 16°44.23′S, 115°32.10′E; water depth: 2167.9 m.

Hole 761C

The Triassic sequence of Hole 761C is dominated by calcareous sediments and can be subdivided on the basis of its microfossil content into five intervals, which also reflect environmental changes (Fig. 4). The lowermost interval (Core 122-761C-33R) consists of clayey siltstone, and its fossil content (dinoflagellate cysts and nannofossils) suggests a Norian age (Fig. 4). The overlying interval (Cores 122-761C-30R through -32R), with an upward increase in carbonate and corresponding decrease in plant debris, indicate a major facies change and results in different occurrences of the various fossil groups. The nannofossil assemblage and the occurrence of the foraminifer *Triasina oberhauseri* points to a Norian age for this interval (Bralower et al., this volume; Zaninetti et al., this volume), whereas the presence of the ostracode *Ogmoconcha owthorpensis* and the dinoflagellate cyst *Rhaetogonyaulax rhaetica* suggest a Rhaetian age (Dépêche and Crasquin-Soleau, this volume; Brenner, this volume, chapter 23).

The interval from Cores 122-761C-27R through -29R contains only a few ostracodes and foraminifers that are not age-diagnostic. The absence of figured organic material (dinoflagellate cysts, spores, and pollen and plant debris) in this interval indicates highly oxidized conditions.

The overlying section (Cores 122-761C-23R through -26R) consists of dark limestone interbedded with calcareous claystone and contains rich microfossil assemblages. Ostracodes, nannofossils, and palynomorphs suggest a Rhaetian age for this interval, whereas the foraminifers indicate a transitional Norian to Rhaetian age based on the absence of *Triasina hantkeni*. The uppermost Triassic cores of Hole 761C (Cores 122-761C-12R through -22R) contains only foraminifers that indicate a Rhaetian age.

Site 764

Location: 16°33.96′S, 115°27.43′E; water depth: 2698.6 m.

Hole 764B

The base of the Triassic sequence (Core 122-764B-31R) consists of calcareous claystone to wackestone and contains rich nannofossil, ostracode, and palynomorph assemblages indicating a Rhaetian age (Fig. 5). This interval is overlain by a limestone sequence with a reef complex (Cores 122-764B-9R through -30R). A rich microfauna of foraminifers, also with *Triasina oberhauseri* and *Triasina hantkeni* (Zaninetti et al., this volume), and a few nannofossils could be found in this section. The upper part of the Triassic sequence (Cores 122-764B-4R through -8R) consists of calcareous claystone and limestone with rich microfossil assemblages indicating a Rhaetian age.

DISCUSSION AND CORRELATION

The Carnian to Norian sequence at Sites 759, 760, and 761 can be subdivided into three biozones based predominantly on palynomorphs. Carnian sediments occur exclusively in the lower part of Hole 759B, whereas Norian sediments occur at all three sites (Fig. 6).

The zonation used at these sites is based on a combination of spore/pollen zones and dinoflagellate cyst zones. An intermediate interval of Carnian to Norian age is proposed for parts of Holes 759B, 760A, and 760B, but some discrepancy exists between spore/pollen and dinoflagellate cyst chronostratigraphy. Two different explanations or a combination of both possibilities can be offered: The spore/pollen zonal boundary of the *Samaropollenites speciosus* and *Minutosaccus crenulatus* Zones are either diachronous with respect to those of the dinoflagellate cyst *Shublikodinium wigginsii* and *Suessia listeri* Zones and/or the occurrence of *Suessia listeri* in this interval is facies-controlled. Therefore, there may be overlap between the upper (intermediate) Carnian-Norian part of Hole 759B and the lower (intermediate) part of Hole 760B. The presence of the ostracode *Cytherella acuta* in Core 122-759B-11R indicates a late Norian to Rhaetian age. Therefore, we cannot exclude the possibility that the upper part of the intermediate zone of Hole 759B is younger than the apparent equivalent interval in Hole 760B.

The Norian/Rhaetian boundary was only observed in Hole 761C. The change of ecologic parameters and/or the diachronous occurrence of the different fossil groups suggests that this boundary lies between Core 122-761C-32R (based on ostracodes and dinoflagellate cysts) and Core 122-761C-30R (based on nannofossils). A higher placement of the Norian/Rhaetian boundary as suggested by the first occurrence of the foraminifer *Triasina hantkeni* in Core 122-761C-23R may be controlled by ecological factors, as this species is associated with shallow-marine conditions.

A fossiliferous interval from Cores 122-761C-23R through -26R indicates open-marine conditions, based on foraminifers, nannofossils, and palynomorphs. The interval from Cores 122-761C-12R through 122-761C-22R contains only foraminifers and the interval from Cores 122-761C-27R through 122-761C-29R contains also only foraminifers and a few ostracodes. The absence of nannofossils and palynomorphs within these intervals point to oxidized and respectively shallow-marine conditions.

The Rhaetian sequence of Site 764 can be divided on the basis of its fossil content into three intervals. The basal interval in Core 122-764B-31R contains rich assemblages of nannofossils, palynomorphs, and ostracodes, which indicates open-marine conditions. The presence of the nannofossils *Eoconusphaera zlambachensis, Crucirhabdus minutus,* and *Archaeozygodiscus koessenensis* suggests that this interval can be correlated with the interval from Cores 122-761C-23R through -26R from Hole 761C. The interval from Cores 122-764B-9R through -30R consists of oxidized shallow-marine limestones with a reefal complex. Only a rich microfauna of foraminifers and a few nannofossils could be found (Fig. 5). The same open-marine to shallow-marine succession of Sites 761 and 764, within the Rhaetian sequence, suggests that the intervals from Cores 122-761C-12R through -22R and from Cores 122-764B-9R through -30R are correlatable, whereas the interval at Site 761 represents the proximal part of the reefal complex at Site 764. The uppermost part of the Rhaetian sequence at Site 764 (Cores 122-764A-6R through -8R and 122-764B-4R through -8R) once again contains open-marine microfossil assemblages. Based on the size of certain nannofossils (Bralower et al., this volume) this interval is interpreted as younger than the top of the Rhaetian sequence at Site 761.

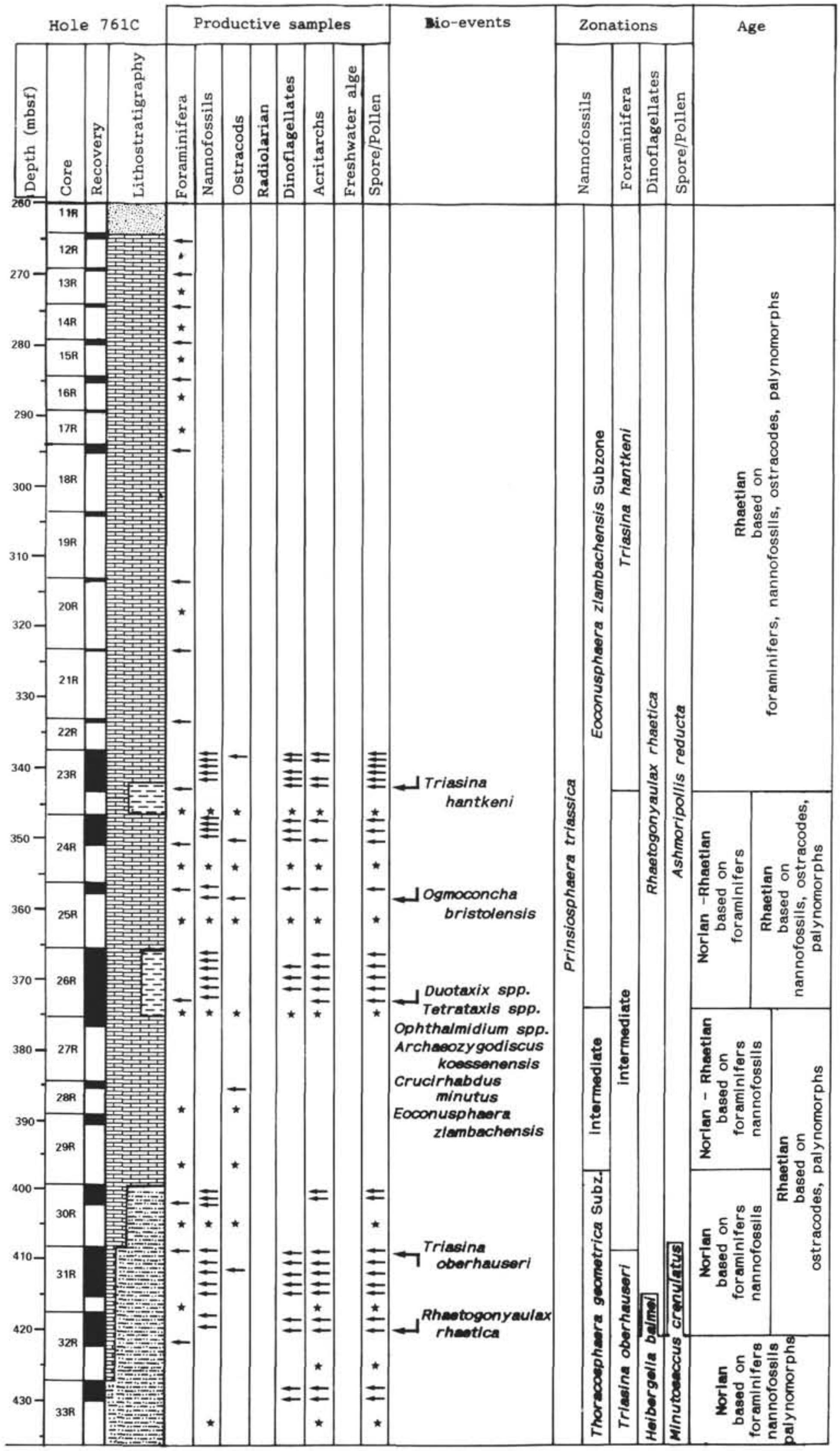

Figure 4. Biostratigraphic zonation of Hole 761C with location of fossiliferous samples. See Figure 2 for key to symbols.

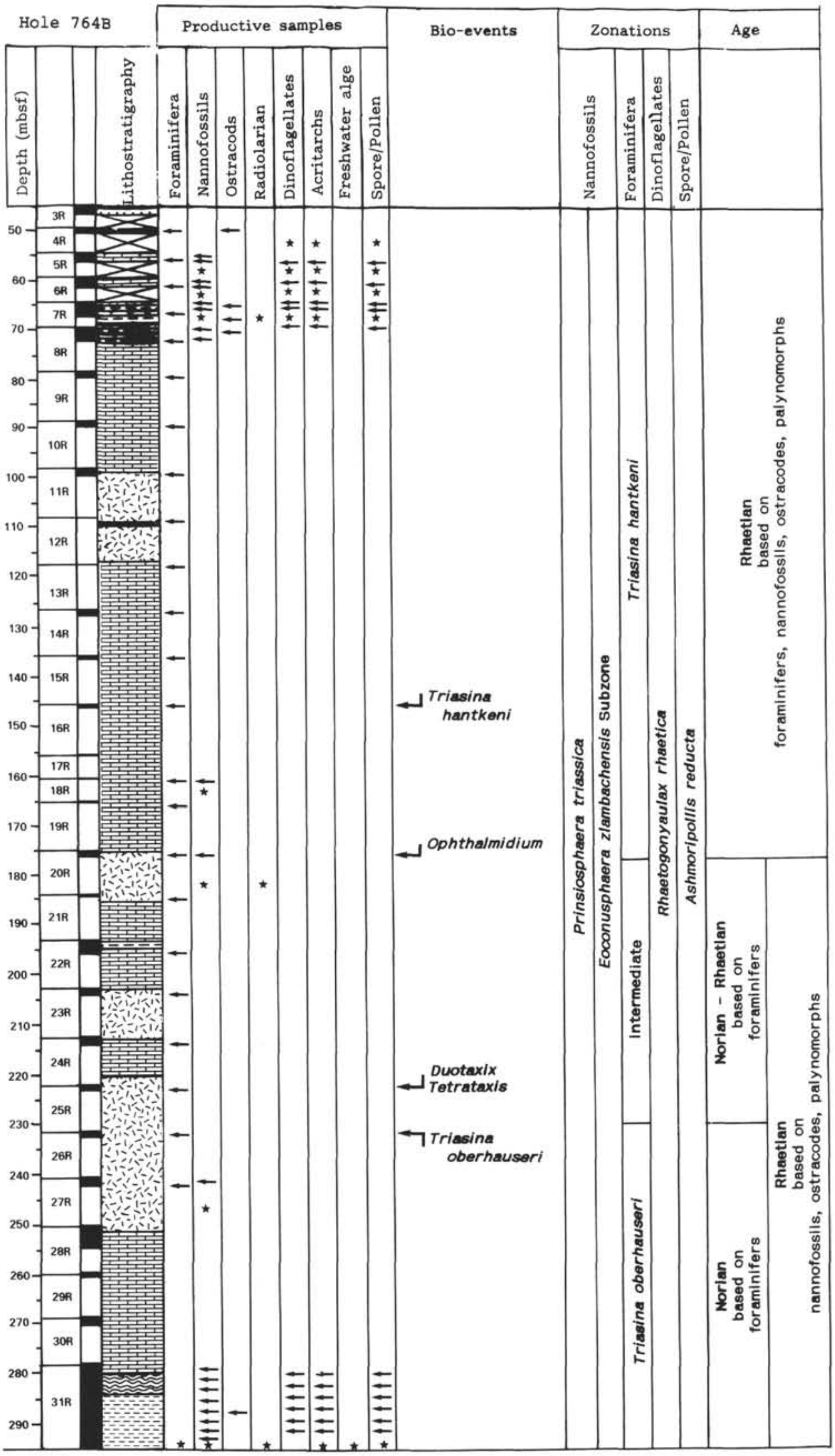

Figure 5. Biostratigraphic zonation of Hole 764B with location of fossiliferous samples. See Figure 2 for key to symbols.

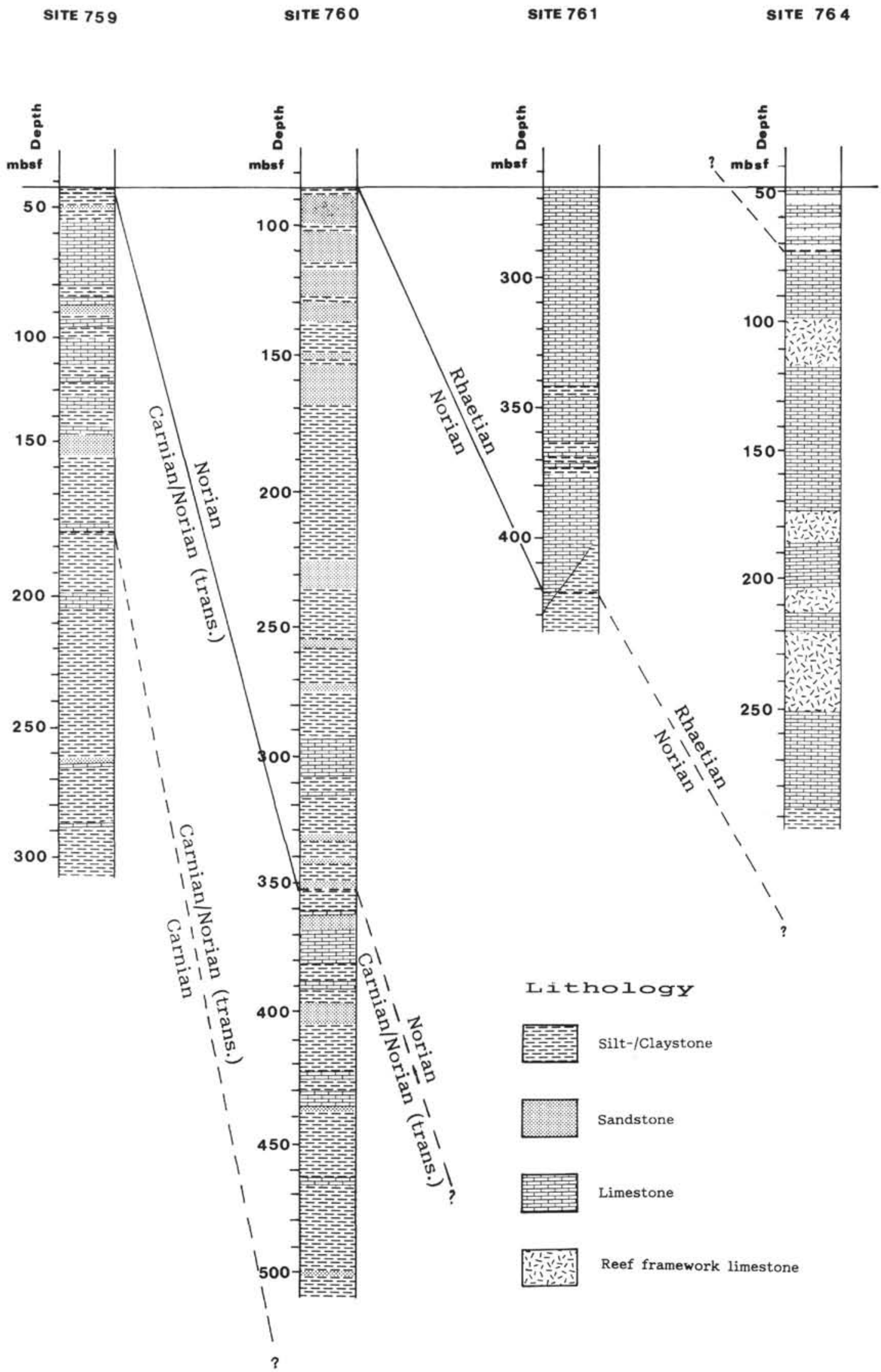

Figure 6. Age correlation of Sites 759, 760, 761, and 764.

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