Wefer, G., Berger, W.H., Richter, C., et al., 1998
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19. BIOSTRATIGRAPHIC AGE MODELS AND SEDIMENTATION RATES ALONG THE SOUTHWEST AFRICAN MARGIN[1]

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BACKGROUND

During Leg 175, 13 sites were drilled off the western and southwestern coasts of Africa. This area is one of the most productive regions of the world ocean. The combination of high productivity in surface waters and a tectonically quiet setting (passive margin) resulted in the deposition of fossil- and organic-rich sediments accumulating at high rates on the eastern flank of the Congo, Angola, and Cape Basins. Locally, high terrigenous supply from rivers, such as the Congo River, as well as coastal erosion, as occurs off Angola, dilute the biogenic component of the sediment and result in increased sedimentation rates.

The main objective of Leg 175 was to reconstruct the late Neogene history of productivity and associated circulation and upwelling dynamics of the Benguela Current system. Considering the high rates at which sediments accumulate in this region, the shipboard micropaleontologists were called on to provide a high-resolution stratigraphic framework and paleoecological analysis, with particular emphasis on the Pleistocene and Pliocene sections.

The shipboard analysis provided age estimates at an average resolution of 200 k.y. for most of the Pleistocene and upper Pliocene intervals of the recovered section. The biostratigraphic resolution of the lower Pliocene and Miocene intervals was somewhat coarser but still in the range of 500 k.y. This was accomplished despite a very high rate of core recovery and variable preservation of fossil assemblages.

Although all investigated microfossil groups provided valuable information, calcareous nannofossils were critical to the construction of a detailed biostratigraphy. Being abundant in sediments deposited under either high or low productivity conditions, this species group was less affected by environmental constraints than were, for instance, siliceous microfossils. Also, calcareous nannofossils were found to be more resistant than planktonic foraminifers to diagenetic processes, which characterized most of the organic-rich intervals of the recovered sections. Finally, the resolution of the nannofossil-based biostratigraphy was improved by integrating acme intervals of species/taxonomic categories, in addition to the classical first and last occurrence of index species. These isotopically calibrated intervals (see “Explanatory Notes” chapter, this volume) were crucial to the improvement of the stratigraphic resolution of the Pleistocene.

The biostratigraphic utility of planktonic foraminifers was strongly hampered by selective dissolution and pyritization in the most organic-rich sites. However, the carbonate-rich southernmost sites from the Mid-Cape Basin (MAB) and Southern Cape Basin (SCB) (Sites 1085–1087) contained abundant, unaltered planktonic foraminifers that were used to erect a biostratigraphy independent from the calcareous nannofossils and siliceous microfossil groups. The planktonic foraminiferal datum events for the Pliocene and Miocene intervals were particularly useful.

Although mostly used as indicators of environmental changes (upwelling intensity, surface circulation, and freshwater input), siliceous microfossils (diatoms, radiolarians, and silicoflagellates) provided important age control in sediments deposited under high-productivity regimes. This is particularly true for the sites close to the major upwelling centers off Namibia (Site 1081 on the Walvis Ridge; Sites 1082 and 1083 in the Walvis Basin; and Site 1084 off Lüderitz), as well as for the sites occupied in the peri-estuarine environment off the Congo River. Because the calcareous microfossils, especially the planktonic foraminifers, were commonly affected by dissolution in the high-productivity region off the Congo River, the biostratigraphic information provided by siliceous microfossils was invaluable at these shallow-water coastal sites.

The biostratigraphic analysis of the 13 sites indicates an overall continuous hemipelagic sedimentation occurring at a rate of ~10 cm/k.y., or greater. Age estimates and sedimentation rate patterns inferred from the vertical distribution of microfossils was commonly in close agreement with the magnetostratigraphy developed on board, which suggests absence of (or only minor) postdepositional sediment transport. Shore-based refinement of the magnetostratigraphy from analyses of discrete samples, as well as the future development of an oxygen-isotope stratigraphy for every site occupied, will provide an opportunity to improve the calibration of the Neogene microfossil datum events identified in the sedimentary sections from Leg 175.

A synthesis of Leg 175 sites is presented and organized by basin. Comparisons are made between sites drilled from a specific geographic setting. Only 12 of the 13 sites that were drilled are discussed. Site 1080, excluded from this synthesis, was drilled off the Kunene River but only penetrated to 52 meters below seafloor (mbsf). The poor recovery was attributed to the presence of hard dolomite layers.

LOWER CONGO BASIN (LCB)

Located at different positions with respect to the Congo Canyon and Congo Fan, Sites 1075, 1076, and 1077 are distributed at varying distances from the shelf break. The shipboard biostratigraphic analyses (Fig. 1) suggest an overall decreasing sedimentation rate (i.e., reduced contribution of terrigenous input) with distance from shore. Average sedimentation rates range from 10 cm/k.y. for the deeper Site 1075 (water depth: 2995 m) to 15 cm/k.y. for the shallower Site 1076 (water depth: 1404 m). Sediments sampled at the intermediate Site 1077 accumulated at an average rate of 12 cm/k.y. Consequently, Site 1075 penetrated the upper Pliocene sediments, whereas Sites 1077 and 1076 did not reach sediments older than 1.7 and 1.3 Ma, respectively. The bottom age of Site 1077 is estimated from magnetostratigraphic data. Based on evidence for coring-induced magnetiza-

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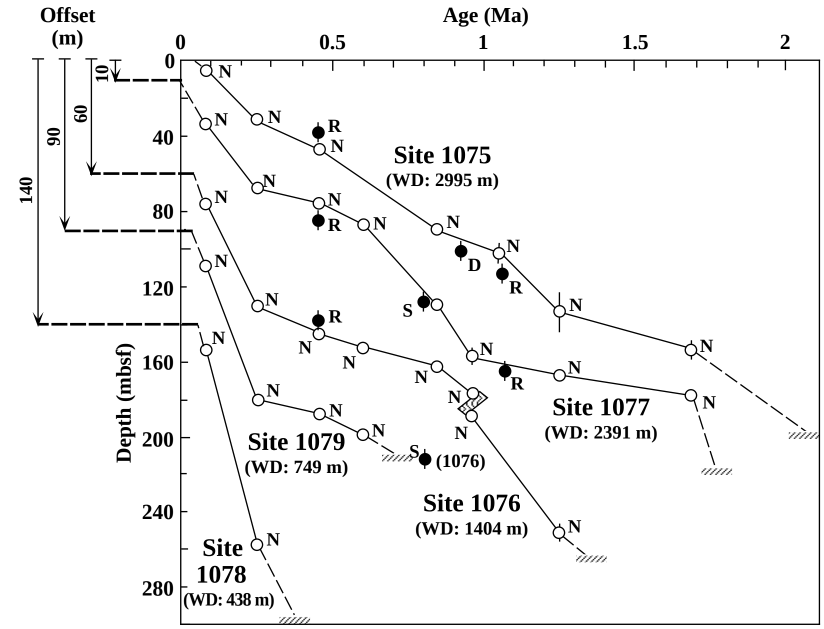

Figure 1: Biostratigraphic summary of the Leg 175 sites drilled in the Lower Congo Basin (Sites 1075, 1076, and 1077) and Mid-Angola Basin (Sites 1078 and 1079). Open circles = calcareous microfossils (N = calcareous nannofossils); solid circles = siliceous microfossils (R = radiolarians, D = diatoms, and S = silicoflagellates); WD = water depth. Hatched regions indicate the maximum penetration at the sites.

tion below 148 mbsf (see "Paleomagnetism" section, "Site 1077" chapter, this volume), this bottom age is tentative and should be reviewed after detailed shore-based paleomagnetic measurements.

Common to the three LCB sites is the low abundance and poor preservation of calcareous microfossils in sediments older than ~0.7 Ma. The shallow Site 1076 shows evidence of common reworked shelf material. This, together with the overall poor preservation of calcareous nannofossils, might explain the disagreement between the magnetic- and microfossil-derived stratigraphy between 0.7 and 1 Ma (see "Biostratigraphy and Sedimentation Rates" section, "Site 1076" chapter, this volume).

MID-ANGOLA BASIN (MAB)

Sites 1078 and 1079, cored in the Bight of Angola, sampled an apparently continuous late Pleistocene record of predominantly terrigenous origin. The calcareous nannofossil-derived biostratigraphy suggests that the deeper Site 1079 terminated at ~0.7 Ma (maximum penetration: 128 mbsf), whereas the shallower Site 1078 (maximum penetration: 165 mbsf) did not reach sediments older than ~0.35 Ma (Fig. 1).

Sediments younger than 0.26 Ma accumulated at a record rate compared with those recovered from other Leg 175 sites, reaching 60 cm/k.y. at Site 1078. Siliceous microfossils were only sporadically present within two short laminated organic-rich intervals and were therefore of limited stratigraphic interest.

WALVIS RIDGE AND WALVIS BASIN

Sites 1081, 1082, and 1083 are located on the Walvis Ridge and in the Walvis Basin within an area that is affected by filaments originating from the northern Namibian upwelling cells. Drilling at all sites recovered continuous hemipelagic sections extending into the upper Pliocene (Site 1083) or the upper Miocene (Sites 1082 and 1081; Fig. 2A, B). The biogenic fraction of sediments recovered from these sites contains relatively abundant siliceous microfossils down to the lower Pliocene section. Consequently, an integrated high-resolution stratigraphic framework composed of both calcareous and siliceous microfossil datum events could be established. The mean average sedimentation rates at the Walvis Basin sites range from 11 cm/k.y. for the shallower Site 1082 (water depth: 1279 m) to 7 cm/k.y. for the deeper Site 1083 (water depth: 2178 m). Sediments recovered from the shallow Walvis Ridge Site 1081 (water depth: 794 m), accumulated at a relatively slow rate (5 cm/k.y. on an average), a possible indication of strong bottom currents at this particular setting.

The biostratigraphic framework for the Pleistocene interval is particularly well constrained, with a resolution close to 150 k.y. Sedimentation rates within the last 1.4 Ma are relatively constant for each of the sites. Early Pleistocene and older sediments accumulated at a more variable rate. The Pliocene/Pleistocene boundary between ~2 and 1.7 Ma is characterized by an increased sedimentation rate at all three Walvis sites. This increase in accumulation resulted from an increase in deposition of diatom skeletons. The ecologically-induced absence of several nannofossil index species within the bottom half of Sites 1082 and 1081 strongly hampered the biostratigraphic resolution of the early Pliocene and late Miocene intervals.

CAPE BASIN

Site 1084 is located off Lüderitz, near the currently most active coastal upwelling cell of the Benguela region. This cell maintains a central position within the system and is believed to have remained active throughout the late Neogene, irrespective of latitudinal shifts of the South Atlantic high-pressure cell and associated southeasterly winds. Sediments retrieved from Site 1084 contained record contributions of organic carbon and biogenic opal. The high-resolution biostratigraphic framework developed at this site is therefore based on a combination of siliceous and calcareous microfossil datum events. Drilling at Site 1084 recovered a continuous sequence extending into the lower Pliocene (bottom age: ~4.7 Ma), with sediments accumulating at a mean rate of 13 cm/k.y. (Fig. 3A, B). Pleistocene sediments accumulated at a high rate of 18 cm/k.y., with peaks of 27 cm/k.y. between 0.8 and 1 Ma. The uppermost Pliocene was also characterized by high accumulation rates close to 17 cm/k.y. These two episodes of increased sedimentation rates at the Pleistocene revolution and during the latest Pliocene occur in association with two distinct depositional peaks of diatom skeletons: a *Chaetoceros*-rich interval in the Pleistocene part of the section and *Thalassiotrix* mat-like structures in upper Pliocene sediments.

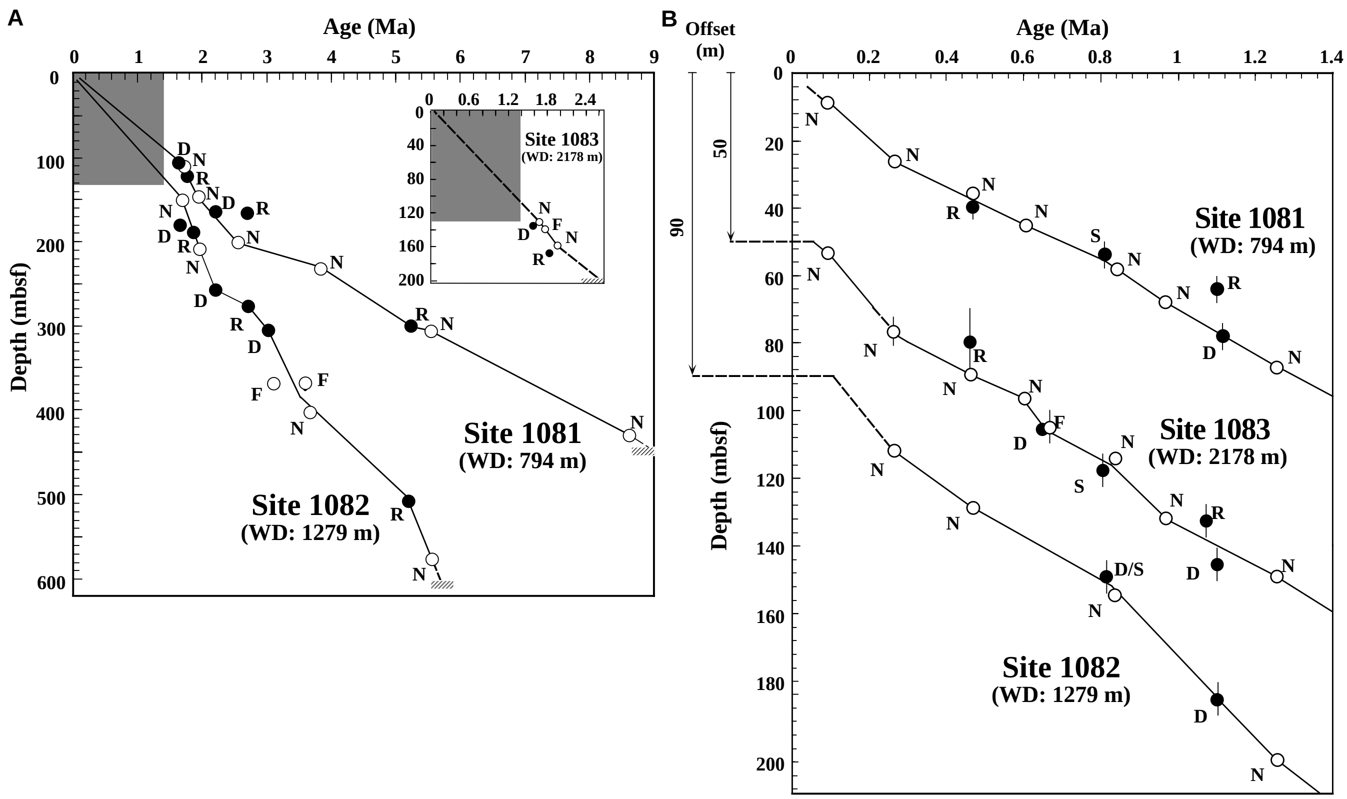

Figure 2: Biostratigraphic summary of the Leg 175 sites drilled on the Walvis Ridge (Site 1082) and Walvis Basin (Sites 1082 and 1083) **A.** Miocene and Pliocene. **B.** Last 1.4 m.y. Open circles = calcareous microfossils (N = calcareous nannofossils and F = planktonic foraminifers); solid circles = siliceous microfossils (R = radiolarians, D = diatoms, and S = silicoflagellates); WD = water depth. Hatched regions indicate the maximum penetration at the sites.

Sites 1085, 1086, and 1087 were cored in the SCB, an area affected by highly seasonal and less intense upwelling conditions. Mean average sedimentation rates estimated from the calcareous microfossil-based biostratigraphy are close to 4 cm/k.y. for the three sites. Drilling at Site 1085 recovered a continuous sedimentary record from the present down to 16 Ma in the middle Miocene. The shallow-water Site 1086 penetrated late Miocene sediments but did not recover sediments younger than 1.6 Ma. Finally, Site 1087, the last site cored during Leg 175, was the only one to contain evidence of major stratigraphic discontinuities. These stratigraphic anomalies affected the lowermost 70 m of sediment; the overlying 530-m-long section maintained nearly continuous sedimentation from ~9 Ma to the present.

Common features of the three SCB sites are (1) an episode of increased sedimentation rate across the Miocene/Pliocene boundary between ~5 and 6 Ma, (2) the rare presence or absence of siliceous microfossils in sediments older than 3 Ma, and (3) the distinct presence of dinoflagellate cysts in the late Miocene.

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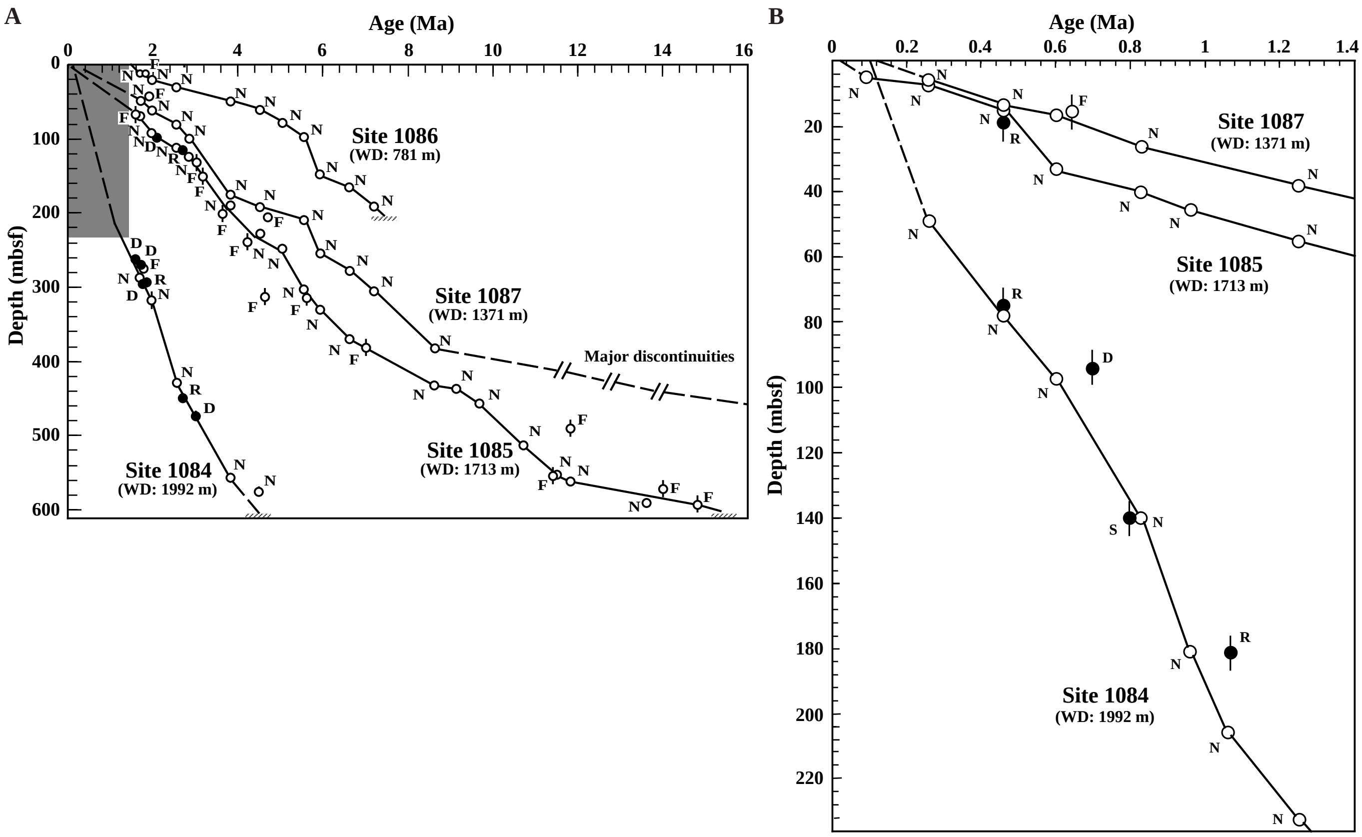

Figure 3: Biostratigraphic summary of the Leg 175 sites drilled in the Northern (Site 1084), Mid- (Site 1085) and Southern Cape Basins (Sites 1086 and 1087). **A.** Miocene and Pliocene. **B.** Last 1.4 m.y. Open circles = calcareous microfossils (N = calcareous nannofossils and F = planktonic foraminifers); closed circles = siliceous microfossils (R = radiolarians, D = diatoms, and S = silicoflagellates); WD = water depth. Hatched regions indicate the maximum penetration at the sites.