8. PLANKTONIC FORAMINIFERAL FAUNAL TURNOVERS DURING THE PALEOCEN-EOCENE TRANSITION

The latest Paleocene-warming event is referred as the late Paleocene thermal maximum (LPTM) by Zachos et al. (1993). This event is placed around the Paleocene/Eocene boundary, and associated with some paleoceanographic changes such as the strong negative excursion of δC^{13} values (CIE) and extinction of bathyal benthic foraminifers (BEE) (e.g. Kennett and Stott, 1990; Thomas and Schakleton, 1996). Based on planktonic foraminiferal biostratigraphy, the CIE and BEE events are placed within Zone P5 (e.g. Berggren and Aubry, 1996; Aubry et al., 1996).

In this study, an attempt is made to understand the effect of this late Paleocen global warming on the pelagic planktonic foraminifera. For this purpose, along with detailed planktonic foraminiferal bistratigraphy, quantitative analysis such as species relative abundance and species diversity for the late Paleocen part was done. Moreover, the studies on the benthic forminifera are also carried on in order to mark the benthic foraminiferal event (BFEE).

8.1 Species relative abundance

The morozovellid species are common to abundant throughout the studied sequences, and exceed about 30-40% of total specimens (Figures 13, 14, 15). The morozovellid group was dominated by *M. angulata* in Zone P3B, *M. acuta* and *M.*

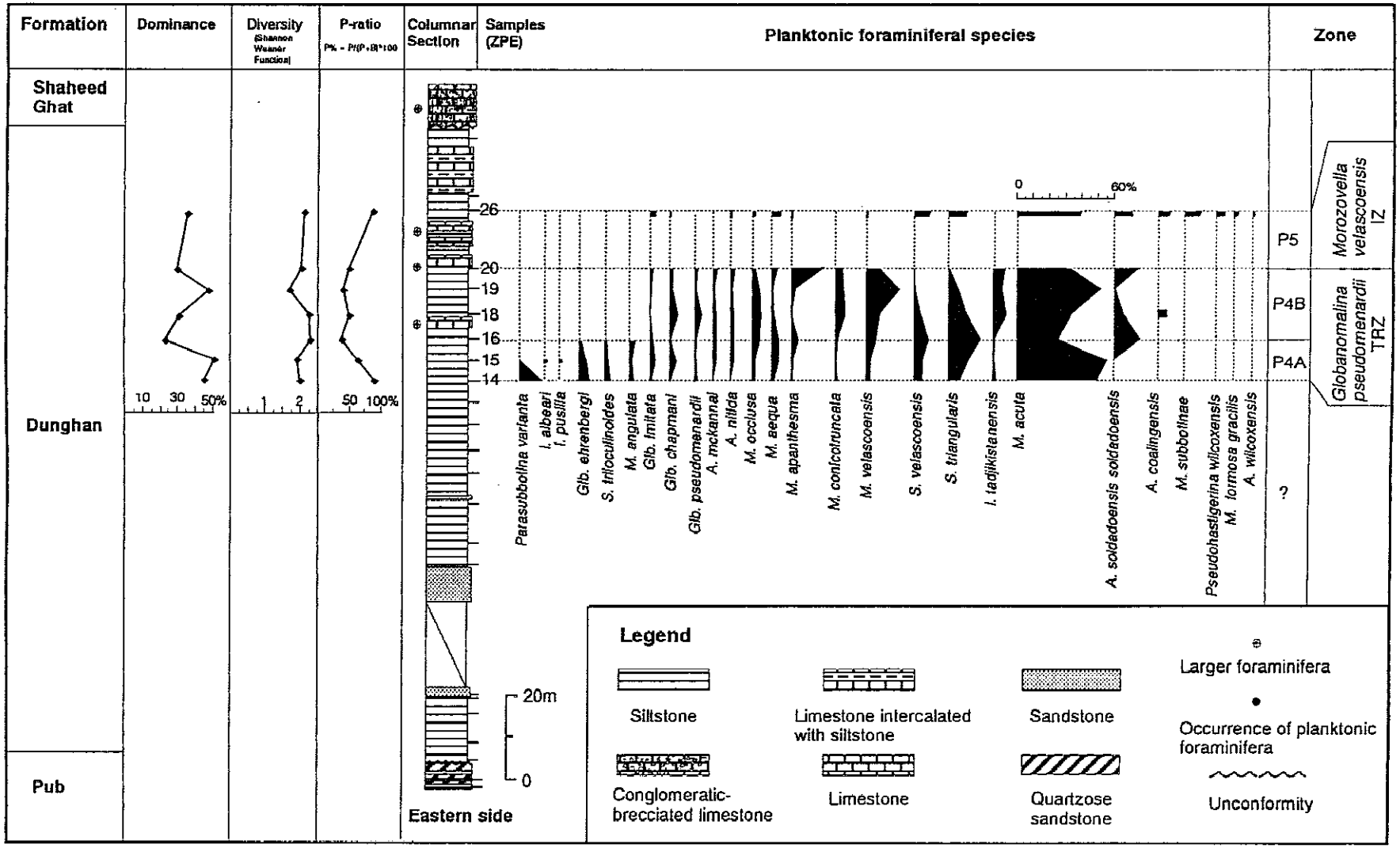

Figure 13. Dominance (the most abundant taxon; *M. acuta*), diversity, P- ratio and relative abundances of the characteristic planktonic foraminiferal species with lithology, biostratigraphy and position in the measured columnar section along the eastern limb of the Zinda Pir Anticline. The numbers indicate the samples containing planktonic foraminifers whereas small horizontal lines against lithology indicate samplepositions.

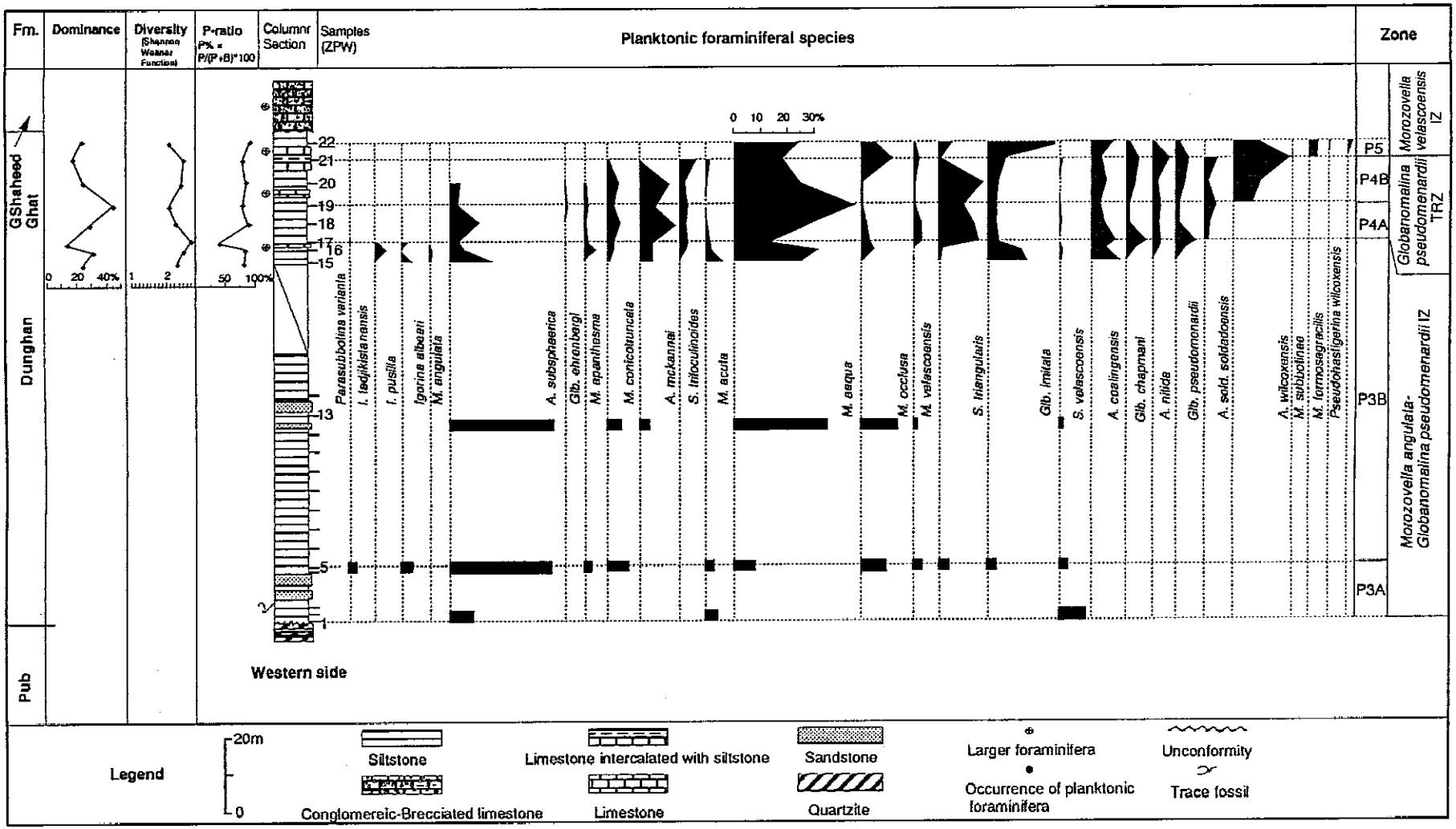

Figure 14. Dominance (the most abundant taxon; *M. acuta*), diversity, P- ratio and relative abundances of the characteristic planktonic foraminiferal species with lithology, biostratigraphy and position in the measured columnar section along the western limb of the Zinda Pir Anticline. The numbers indicate the samples containing planktonic foraminifers whereas small horizontal lines against lithology indicate sample positions.

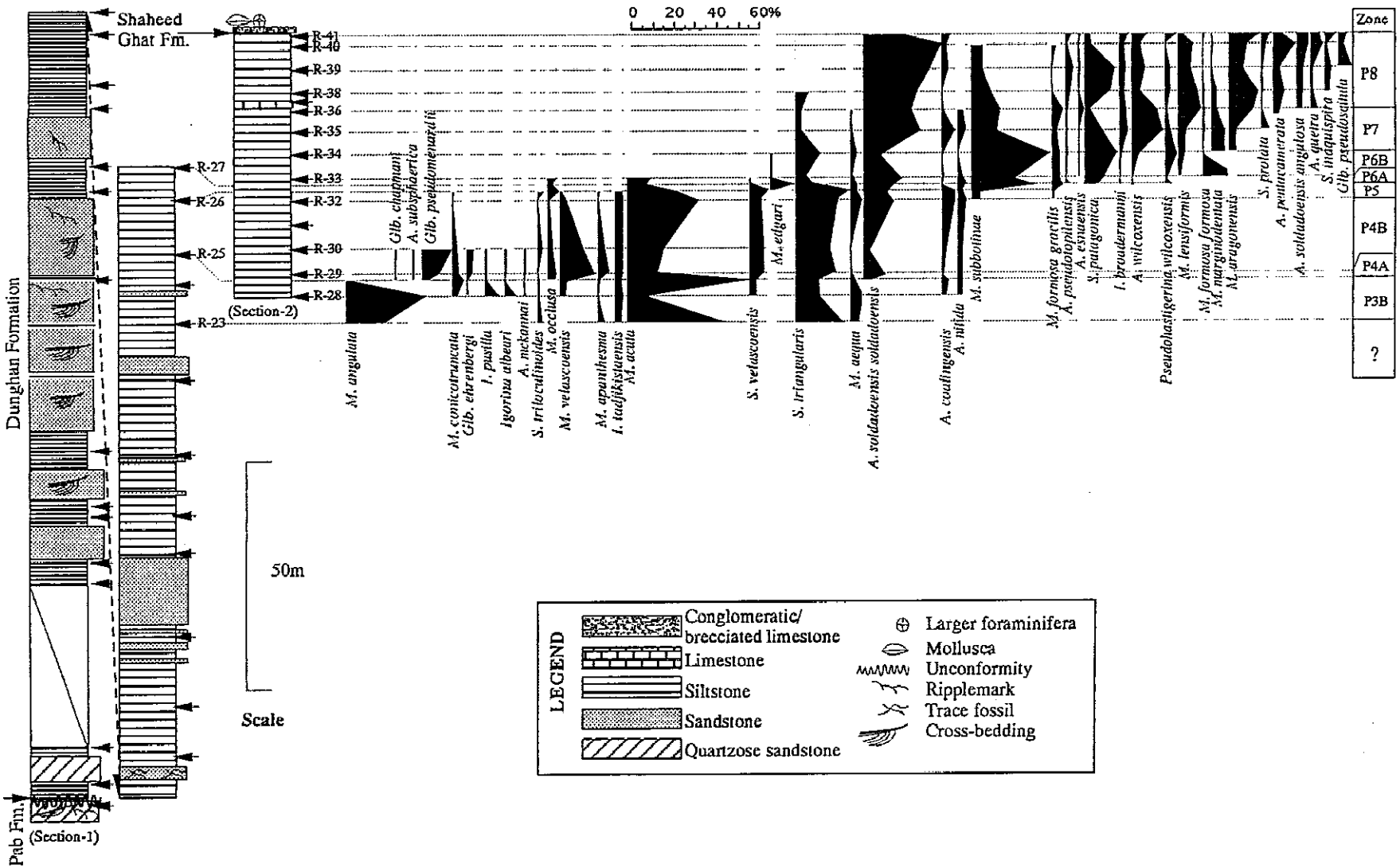

Figure 15. Dominance (the most abundant taxon; *M. acuta*), diversity, P–ratio and relative abundances of the characteristic planktonic foraminiferal species with lithology, biostratigraphy and position in the measured columnar section from Rakhi Nala section. The numbers indicate the samples containing planktonic foraminifers whereas small horizontal lines against lithology indicate sample positions.

velascoensis in Zone P4, and finally three species (*M. acuta, M. subbotinae*, and *M. aequa*) in Zone P5 in the Zinda Pir sections. In the Rakhi Nala section, Zone P3B is dominated by *M. acuta* and *M. agulata* (40 to 60%), and Zones P4 to P5 by *M. acuta, M. conicotruncata, M. occlusa, M. velascoensis* (30 to 35%). The increase of species richness of *Morozovella* may suggest the expansion into new ecological niche in tropical planktonic fauna. The abundance of the genus *Acarinina* and *Subbotina* are relatively high, fluctuating between 10 and 20%, while the other genera (*Igorina, Globanomalina*, and *Parasubbotina*) are generally less than 10%.

In Zones P6 to P7 an incoming morozovelid group (*M. formosa gracilis, M. formosa formosa, M. lensiformis, M. subbotina, M. marginodentata* and *M. edgari*) replace an outgoing morozovellid group *(M. velascoensis, M. angulata, M. conicotruncata and M. apanthesma*). Zones P7 to P8 are dominated by acarininids (*A. pentacamerata, A. sold. soldadoensis, A. wilcoxensis)* and subbotinids (*S. patagonica, S. inaquispira, S. prolata*). This decrease in relative abundance of the morozovellid species and marked increase in the acarininids / subbotinids are probably due to the return of cold environment after the Paleocene-Eocene transition.

8.2 Discussion and remarks

The climate reached its warmest temperatures of the Cenozoic during the Paleocene-Eocene transition, accompanied by the lowest average δC^{13} values as reported by Shackleton et al. (1985), Shackleton (1986), Miller et al. (1987), Corlfield and Shackleton (1988) and Kennet and Stott (1990, 1991). Deep water temperatures

rose between 10C° and 15C° whereas surface waters remained relatively stable at low latitudes, however, an increase of 5C° to 7.5C° is reported in Antartic waters (Corlfield and Shackleton, 1988; Kennet and Stott, 1990. 1991; Pak and Miller, 1992, Lu and Keller, 1993, 1995a, b). These climatic changes associated with other major changes in the oceanic deep water circulation caused a temporary absence of cold deep water formation in the Antarctica and on the other hand, production of the warm saline waters in the Tethys region, are generally considered the possible causes for the isotopic excursion accompanied by benthic foraminiferal mass extinction (Kennet and Stott, 1990; Pak and Miller, 1992; Lu and Keller, 1993; Lu et al., 1996). Now many workers support that the Teths region was the main source for the warm deep saline waters (Kennet and Stott, 1990. 1991; Pak and Miller, 1992, Lu and Keller, 1993, 1995a, b; Canudo et al., 1995). Pardo et al. (1997) have said that the abrupt planktonic foraminiferal extinction at Caravaca or Alamedilla during the P-E transition as compared with Zumaya in the northern Spain which is influenced by cold waters and well oxygenated Atlantic waters (Canudo et al., 1995, Ortiz, 1995; Arenillas and Molina, 1996)

In the studied sections from the Sulaiman Range, Southern Indus Basin, some faunal turnovers were recorded at the P4B/P5 boundary or within Zone P5 (Figures 13~15). Moreover, Dr. Noumura of Shimane University who is presently working on the benthic foraminiferal fauna from the same sample with the author has detected benthic foraminiferal extinction event (BFEE) between samples R-32 and R-33 from Rakhi Nala section. The following 7 species, became extinct: *Acarinina*

mckannai, Globanomalina chapmani, Glb. pseudomenardii, Igorina tadjikistanensis, Morozovella apanthesma, M. conicotruncata, and *Subbotina triloculinoides.* In other tropical regions, the LADs of these species were placed at the Zone P4b/P5 boundary, except for two species of *I. tadjikistanensis* and *Glb. chapmani* which survived and disappeared later within Zone P5 (Berggren and Norris, 1997; Olsson et al., 1999). However, the species diversity of the eastern section during the Paleocene-Eocene transition (Zone P5) is constant of 2.0. Because dominant species of *Morozovella acuta* group (*acuta, velascoensis*) occupy consistently 10-30% of total specimens during the Paleocene/Eocene boundary, the extinction of other genera such as *Acarinina*, *Igorina* and *Subbotina* gave little influence, as a whole, for species diversity of the Dunghan Formation. In the western section, the drop of species diversity within Zone P5 results from a lowering of equitability due to rapid increase of *S. triangularis*. These results suggest that tropical dominant fauna of the *Morozovella* group was not seriously affected by the global warming during the Paleocene/Eocene transition in the Central Pakistan area, while other species of *Acarinina, Subbotina* and *Globanomalina* were slightly damaged and changed their faunal assemblage.

Hence it is concluded that there occurred at least some faunal turnover in the planktonic foraminifera around Zones P4B/P5 boundary or within Zone P5, close to the Paleocene/Eocene boundary.