20. LATE CENOZOIC POLLEN HISTORY FROM SITE 765, EASTERN INDIAN OCEAN¹

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ABSTRACT

Middle Miocene to Holocene pollen assemblages reveal a history of environmental change in northern Australia. Grass pollen appeared, but was rare, in the late Miocene and was consistently present throughout the Pliocene, but did not become abundant until the Pleistocene. Myrtaceae pollen, characteristic of late Cenozoic assemblages in eastern Australia, is poorly represented, and no unequivocal evidence of rain forest was found.

INTRODUCTION

There are many pollen-based studies of late Cenozoic vegetative history in eastern Australia (Truswell et al., 1982; Stover and Partridge, 1973; Martin, 1977; Kershaw, 1988), but there are no published reports of any in the northwestern section of the continent. Site 765, which is located off northwestern Australia on the Argo Abyssal Plain, is well sited to provide pollen data from this poorly known region of continental Australia.

Site 765 contains an almost complete Holocene to Early Cretaceous (Berriasian) sequence. The Cenozoic sequence is composed primarily of calcareous turbidites and pelagic oozes. Cenozoic pollen assemblages were obtained only from the middle Miocene to Holocene, as older samples were barren. There is some evidence from the foraminifera and nannoplankton assemblages of reworking from earlier in the Cenozoic. Middle to Late Jurassic spores and dinoflagellates are ubiquitous in the late Cenozoic assemblages, but there is no evidence of Cenozoic reworking of palynomorphs into either the dinoflagellate or pollen assemblages.

Methods

The samples were prepared using standard palynological procedures (see McMinn, this volume). Preparations examined for pollen are the same as those examined for dinoflagellates (McMinn, this volume); these are stored in the palynological collection of the N.S.W. Geological Survey and are referred to by an MMMC catalogue number. All pollen in a preparation was counted, and these data are presented in Tables 1 and 2. Ages have been inferred from the foraminifers, nannoplankton, radiolarians, and dinoflagellate data (Ludden, Gradstein, et al., 1990).

POLLEN IN MARINE SEDIMENTS

Marine sediments contain a better record of the regional vegetation and climate than most continental deposits (Heusser, 1986/87). In a review of research on deep sea cores in the northeast Atlantic Ocean, northwest Pacific Ocean, and Arabian Sea, Heusser (1986/87) demonstrated that over the last 140,000 yr, climatic records derived from pollen of the land-based vegetation are in agreement with those derived from marine microfossils (foraminifers and radiolarians) and ice-sheet volume (derived from oxygen isotopes).

Interpretation of pollen in marine sediments relies on surveys of the distribution of pollen in surface sediments and its relationship to the terrestrial vegetation. Heusser (1988) concluded that most studies revealed a systematic distribution of pollen in marine sediments that is related to environmental and sedimentological factors; these factors include the composition of the vegetation. pollen production, dispersal, and eolian, fluvial, and marine transport (Heusser, 1988, p. 132). In a study of the distribution of pollen on the continental margin off northern California, Heusser (1988) demonstrated that pollen rapidly increases seaward on the shelf and is present in relatively large quantities in water depths of greater than 50 m. She also found tongues of high pollen concentration projecting from river mouths toward a submarine canyon. Sediment traps on the mid-slope recorded seasonal changes in pollen abundance, and a similar trend also was found in sediment traps in the rivers. Pollen deposition on the slope was highly correlated with the physical processes involved in the sedimentation of fine-grained, terrigenous particles, demonstrating that in this region, fluvial rather than eolian processes are the major means of transporting pollen from land onto the shelf (Heusser, 1978). Most importantly, Heusser (1988) was able to show that pollen deposited on the California continental margin was derived from contemporary vegetation and clearly reflected the major vegetation formations onshore.

Site 765 is located approximately 400 km from the shelf margin, a distance that would normally preclude the accumulation of significant pollen assemblages. At this location, the pollen assemblages were redeposited by turbidity currents from the outer shelf or slope onto the abyssal plain. All of the pollen would have been produced on the land, transported by wind or water, and deposited on the shelf, then carried by turbidity currents onto the abyssal plain. The presence of Poaceae pollen may possibly infer direct eolian transport, but the co-occurrence with *Acacia* pollen, a large heavy grain that is not transported by wind, would imply that fluvial transport is perhaps more significant. Thus, the pollen probably arrived at Site 765 by complex transport pathways.

Reduced diversity of pollen offshore is often taken to indicate differential pollen destruction (Heusser, 1978). Casuarinaceae and *Cyathea*, which are robust grains, have been found in sediments where almost everything else had been destroyed. However, Poaceae (grass) is a more delicate grain, and yet is still abundant at Site 765, and whole *Acacia* polyad grains, which have a tendency to break up, also are found there. Thus, differential destruction is unlikely to have caused major distortions in the assemblages. Because of the distance and circumstances of deposition, the assemblages are probably somewhat restricted. However, late Cenozoic palynofloras have not been reported from anywhere else in this part of the continent, so this record, despite the low pollen abundances, is particularly important.

¹ Gradstein, F. M., Ludden, J. N., et al., 1992. Proc. ODP, Sci. Results, 123: College Station, TX (Ocean Drilling Program).

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Table 1. Species abundance presented as numbers of grains counted.

	Age	Core, section, interval (cm)	Casuarinaceae	Cyatheae	Restionaceae	Chenopodiaceae	Asteraceae spp.	Acacia	Gyrostemonaceae	Tricolporites spp.	Haloragis	Podocarpus spp.	Poaceae	Dodonaca	Myrtaceae	Tricolporopollenites spp.	Laevigatosporites ovatus	Asteraceae 2	Polypodiidites sp.	Total counted
Quaternary	Pleistocene	1H-2, 142–144 1H-3, 80–82 3H-6, 37–43 4H-3, 60–65 5H-6, 63–65 6H-1, 69–75 7H-6, 56–60 8H-3, 4–6 9H-2, 100–107	9 7 1 6 4	: : : : 1		2 24 16 4 6 1	2 10 5 1 3	· 2 2 · · ·	1 6 1 3 3 1	1		*******	12 52 100 13 22 20		1111	:	: : : :	****		17 106 133 23 44 27
	late Pliocene	10H-1, 123–127 11H-3, 38–42 12H-7, 26–30 13H-3, 78–83 14R-1, 4–6 14H-4, 36–42 15H-6, 28–33 16H-1, 70–74 17H-4, 111–115 18H-5, 48–54	7 12 1 2 6 7 2 5	2	12	2 1 4 2 2	3 1 1	· 1 2 · 1 1 · ·	7 1 1	· · · · · · · · ·			19 10 13 9 9 7 7 6			1	*			43 30 22 2 20 17 10 18
Tertiary	late Miocene	19X-2, 92–94 20X-3, 131–135 21X-5, 126–129 22X-1, 108–110 23X-1, 120–125 24X-3, 85–90 26X-4, 62–68 26X-2, 81–85 27X-1, 92–96 28X-2, 10–15 29X-1, 120–124 30X-1, 75–79 31X-5, 90–95 32X-1, 32–37 33X-4, 88–95 36X-1, 93–97 38X-1, 35–37	6 1 23 7 1 17 9 21 3 7 1	· · · · · · · · · · · · · · · · · · ·	· · · · 35 75511	11.11.14.1	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·	1	1 4 9 20							1 10 2 54 34 1 34 20 50 5 16 2
	middle Miocene	39X-1, 46–52 2R-3, 69–73 3R-3, 41–45 5R-2, 41–43 7R-3, 62–66 8R-2, 61–67 9R-3, 13–14 10R-4, 54–57	1 1 1 2 1	4	1	2	• • • • • •		*						* * * * * * *			*	** ** ** ** ** **	3 2 2 2 5

For explanations and reference to pollen types, see Table 2.

LATE CENOZOIC VEGETATION HISTORY OF SITE 765

Early to middle Miocene: Pollen counts are very low, and one would be imprudent to draw any conclusions.

Late Miocene to middle Pliocene: Casuarinaceae and Poaceae are moderately abundant. *Acacia*, Gyrostemonaceae, and Restionaceae usually are present. Minor amounts of Asteraceae and Chenopodiaeae are evident.

Late Pliocene: The assemblages are much the same as those of the late Miocene to middle Pliocene, but with a slight increase in Poaceae and Asteraceae. Myrtaceae makes a first appearance but is rare.

Pleistocene: There is a considerable increase in Poaceae and Chenopodiaceae, with a modest increase in Asteraceae. Myrtaceae is occasionally present. The major tree types were probably Casuarinaceae, Gyrostemonaceae, and *Acacia*, although all of these taxa may contain shrubby species as well. The palynofloras do not contain any other known tree taxa, except possibly for Myrtaceae, but other species almost certainly were present on the land.

In comparison to southeastern Australia, Myrtaceae forms only a minor component of the assemblages and is not recorded in the northwest until the late Pliocene. In southeastern Australia, Myrtaceae became the major pollen type after the regional decline in rain forest toward the end of the Tertiary, although Casuarinaceae is more abundant than Myrtaceae in some localities. Casuarinaceae, however, was probably more abundant in the northwest part of the continent.

There are no taxa which are unequivocally derived from rain forest but all of the tree taxa, viz Casuarinaceae, *Acacia*, and Gymnostemonaceae contain some rainforest species, as well as The increase in the herbaceous component, viz Asteraceae and Chenopodiaceae and particularly Poaceae, reflects the development of grasslands. This rise exhibits similar patterns to those in central and southeastern Australia. There, Poaceae was rare until the middle Miocene, increased slightly during late Miocene to Pliocene, and became dominant in the late Pliocene to Pleistocene (Martin, 1990a). Poaceae, or grasses, are significant in grasslands, but are also found in both freshwater and saline swamps. Chenopodiaceae is common in desert plant communities (saltbush-bluebush, Martin, 1973b) and in salt marshes. The combination of abundant Poaceae and lesser concentrations of Chenopodiaceae is more likely to reflect extensive grasslands, with some salt marshes. Sluiter and Kershaw (1982) compared late Tertiary pollen spectra from eastern Australia with Holocene pollen assemblages from a variety of vegetation communities. By comparison with these modern pollen spectra, the Site 765 assemblages are consistent with a grasslands origin.

DISCUSSION

The late Cenozoic sequence at Site 765 indicates that rain forest had already declined in northwestern Australia by the beginning of the Miocene. That rain forest was once in the northwest is shown by the two Eocene sites (Fig. 1); El, of early Eocene



Figure 1. Location of Neogene spore-pollen studies for the whole of Australia and northwestern (only) Australian Paleogene studies. 1. Lake Tay, Bint (1981), Pliocene. 2. Ti Tree Basin, Truswell and Harris (1982), Miocene. 3. Lake Frome, Callan and Tedford (1976), Martin (1990a), Miocene. 4. Eyre Peninsula, Truswell and Harris (1982), Pliocene. 5. Oakvale, Truswell et al. (1985), Miocene. 6. SADME MC63, Martin (in press), Miocene-Pliocene. 7. Lake Menindee region, Martin (1988), Miocene. 8. Manilla, MacPhail (1987), Miocene. 9. Western Murray Basin, Truswell (1987), Miocene-Pliocene. 10. Murray Basin, Martin (1977, 1984a, 1984b, 1986), Miocene-Pliocene. 11. Lachlan River Valley, Martin (1973a, 1987), Miocene-Pliocene. 12. Namoi and Gwydir River Valley, Martin (1980), Miocene-Pliocene. 13. Warrumbungle Mountains, Holmes et al. (1983), Miocene. 14. Castlereagh River Valley, Martin (1981), Miocene-Pliocene. 15. Mooki River Valley, Martin (1979), Pliocene. 16. Atherton Tableland, Kershaw and Sluiter (1982), Pliocene-Pleistocene. 17. Queensland, Hekel (1972), Miocene-Pliocene. 18. Sandy Cape, Wood (1986), Miocene. 19. Cooma, Tulip et al. (1982), Miocene. 20. Grange Burn, Harris (1971), Pliocene. 21. Latrobe Valley, Luly et al. (1980), Sluiter and Kershaw (1982), Miocene. 22. Gippsland Basin, Stover and Partridge (1973), Miocene. 23. Regatta Point, Hill and MacPhail (1985), Pliocene-Pleistocene. E1. Goat Paddock, Truswell and Harris (1982), middle-late Eocene. E2. Glen Florrie, Truswell and Harris (1982), middle-late Eocene.

Table 2. Botanical names with corresponding fossil name and reference to where descriptions may be found.

	Age	Core, section, interval (cm)	Batiacasphaera micropapillata	Impagidinium aculeatum	Polysphaeridium zoharvi	Systematophora placacantha	Impagidinium paradoxum	Impagidinium patulum	Operculodinium janduchenei	Impagidinium strialatum	Operculodinium centrocarpum	Operculodinium israelianum	Pyxidinopsis sp.	Spiniferites bulloideus	Spiniferites hyperacanthus	Spiniferites ramosus	Nematosphaeropsis lemniscata
Quaternary		1H-2, 142–144 1H-3, 80–82 3H-6, 37–43 4H-3, 60–65 5H-6, 63–65 6H-1, 69–75 7H-6, 56–60 8H-3, 4–6 9H-2, 100–107		3.0 1.4 3.6 3.9 1.2	1.8 0.7 14.9 9.0 <0.1 21.9		12.1 50.0 3.5 2.5 9.2 8.1 <0.1 6.5	9.1 3.5 3.5 4.6 8.7 <0.1 16.2	0.9 <0.1 1.0 0.3 <0.1 0.8	1.8 7.2 2.4 4.0	12.1 13.2 15.2 2.1 5.4 3.2	9.1 6.1 3.5 3.1 4.2 <0.1 1.2		33.3 50.0 33.3 39.0 28.2 35.9 <0.1 23.5	3.0	11.4 0.7 0.5 0.6 <0.1 0.4	3.0 0.4 2.1 0.9 <0.1 1.6
	Pliocene	10H-1, 123–127 11H-3, 38–42 12H-7, 26–30 13H-3, 78–83 14R-1, 4–6 14H-4, 36–42 15H-6, 28–33 16H-1, 70–74 17H-4, 111–115	· · · ·	3.4 0.9 2.7 2.6 1.2 3.0 7.4	18.6 9.9 16.6 13.0 13.8 36.9 49.5 2.9		7.2 0.5 11.2 7.8 4.4 2.0 8.8	10.6 1.6 6.9 2.6 6.5 2.0 7.4	2.5 0.2 1.5 0.9 2.1 1.0 1.5	1.7 0.2 1.2 2.6 1.8 1.0	1.7 1.4 0.4 13.0 0.9 0.3	7.6 5.9 3.1 13.0 6.0 3.2 3.0 2.9	• • • • •	28.8 53.4 37.1 30.4 39.7 33.0 24.8 48.5	30.4	1.6 1.7 2.1 3.0	0.4 0.5 0.8
Tertiary	late Miocene	$\begin{array}{c} 18\text{H-5}, 48-54\\ 19\text{X-2}, 92-94\\ 20\text{X-3}, 131-135\\ 21\text{X-5}, 126-129\\ 22\text{X-1}, 108-110\\ 23\text{X-1}, 120-125\\ 24\text{X-3}, 85-90\\ 26\text{X-4}, 62-68\\ 26\text{X-2}, 81-85\\ 27\text{X-1}, 92-96\\ 28\text{X-2}, 10-15\\ 29\text{X-1}, 120-124\\ 30\text{X-1}, 75-79\\ 31\text{X-5}, 90-95\\ 32\text{X-1}, 32-37\\ 33\text{X-4}, 88-95\\ 36\text{X-1}, 93-97\\ 38\text{X-1}, 35-37\\ \end{array}$		1.4 1.7	3.0 3.9 58.5 4.3 18.0 39.4 33.6 14.7 . 23.8 64.3 36.2 67.6 14.4 42.1 48.3 56.7 24.3		3.0 1.1 1.5 0.7 4.2 6.1 1.2 2.4 6.0 0.8 0.3 1.0 2.7	0.8 8.8 18.5 2.2 3.0 0.4 1.2 2.6	5.7 0.6 2.2 2.3 27.3 0.9 1.2 <0.1 0.3	1.0 1.7 0.7 <0.1	<0.1 0.3	4.7 3.3 7.9 2.9 3.0		57.2 54.1 7.7 43.2 9.1 41.1 21.1 53.8 35.7 32.5 10.4 60.4 31.6 33.3 23.3 37.8	1.5 0.4 <0.1 0.4	$\begin{array}{c} 1.4\\ 1.1\\ 4.6\\ 2.9\\ <0.1\\ .\\ 1.2\\ 5.2\\ 4.3\\ 9.5\\ .\\ .\\ 1.7\\ 4.2\\ 4.0\\ 2.6\\ 4.3\\ 3.3\\ 5.4\end{array}$	0.8 3.9 <0.1 1.6
	middle Miocene	39X-1, 46–52 2R-3, 69–73 3R-3, 41–45 5R-2, 41–43 7R-3, 62–66 8R-2, 61–67 9R-3, 13–14 10R-4, 54–57	25.0 16.7 28.6	0.2 25.0 14.3	23.9 14.4 19.6 25.0 42.9 2.6 42.9		0.5 9.5 5.1 50.0	1.1 6.5 4.8 5.1 16.7	0.2 25.0 16.7	2.6	2.9 1.4 4.3	11.2 6.9 26.1	0.5 7.7	49.3 59.5 26.1 28.6 28.2	0.7 17.9	2.9 4.8 8.7 2.6	0.2 2.2 4.8

age, contains Anacolosa, Beauprea species, Podocarpus, Dacrydium, Microcachrys and Gunnera; E2, of middle to late Eocene age, contains abundant Nothofagus, Casuarinaceae, Podocarpaceae, abundant and diverse proteaceous pollen, Santalum, and Ericales, all typical of their respective age (Truswell and Harris, 1982). Late Cenozoic sequences from southeastern Australia (Fig. 1), however, demonstrate the decline of widespread rain forest in the middle to late Miocene and its replacement with more open vegetation much of which could have been wet sclerophyll forest, i.e., forest with a tall canopy of Eucalyptus and an understory containing rain forest species. Wet sclerophyll forest is often regarded as transitional between rain forest and dry sclerophyll forest in which Eucalyptus is dominant and rain forest species are absent. In the early Pliocene, there was a minor resurgence of rain forest, with a return to wet sclerophyll in the middle Pliocene and open woodland/grassland in the Pliocene/Pleistocene (Martin, 1987).

In southeastern Australia, where a significant concentration of studied sequences occurs, regional variations in the vegetation become apparent. Thus, during the early to middle Miocene of inland areas, the most abundant pollen groups were Myrtaceae and/or Casuarineceae and/or Araucariaceae, with Myrtaceae or *Nothofagus* the most abundant in the coastal and most southerly region of Australia (Martin, 1990b). These variations in the vegetation suggest a Miocene rainfall gradient parallel to that of today (Martin, 1986). The minor resurgence of rain forest in the early Pliocene also developed with a rainfall gradient parallel to that of today, i.e., there are more species and higher pollen percentages

LATE CENOZOIC POLLEN HISTORY, SITE 765

Table 2 (continued).

	Age	Core, section, interval (cm)	Tectatodinium sp.	Achomosphaera sp.	Impletosphaeridium spp.	Spiniferites mirabilis	Dapsilidinium pasteilsii	Hystrichokolpoma rigaudiae	Operculodinium echigoense	Spiniferites rubinus	Lingulodinium machaerophorum	Operculodinium longispinigerum	Melitasphaeridium choanophorum	Tuberculodinium vancampoae	Spiniferites membranaceus	Impagidinium sphaericum	Schematodinium argoi
Qua	ternary	1H-2, 142–144 1H-3, 80–82 3H-6, 37–43 4H-3, 60–65 5H-6, 63–65 6H-1, 69–75 7H-6, 56–60 8H-3, 4–6 9H-2, 100–107		3.0 0.5 0.9	6.1 5.3 7.8	2.6 7.4 3.1 5.1 2.0	0.9	0.9 1.0 0.3 1.2	0.9 7.7 6.9 <0.1 10.1		0.9 0.7 1.0 1.5 <0.1	3.5 2.8 2.6 2.1 1.6		6.1 0.9 6.7 5.6 1.2 1.2	3.5 1.1 1.5 1.2 2.0	0.4 1.5	•
	Pliocene	10H-1, 123–127 11H-3, 38–42 12H-7, 26–30 13H-3, 78–83 14R-1, 4–6 14H-4, 36–42 15H-6, 28–33 16H-1, 70–74 17H-4, 111–115		0.4 0.5 0.4 0.9 0.3	0.4 2.6 0.3 2.9	3.0 1.1 2.7 8.6 2.9 14.7	0.4 1.6 1.9 0.9 0.3	0.8 2.3 1.2 <0.1 0.6 3.0	5.5 14.2 6.2 2.6 0.3 1.0		2.1 1.1 0.8	1.8 1.5 3.4 1.5 5.0	0.5 0.4 0.9	2.1 0.2 0.8 0.3	0.7 1.5 1.5	2.1 0.8 0.3	0.8 0.9
Tertiary	late Miocene	$\begin{array}{c} 18\text{H-5}, 48-54\\ 19\text{X-2}, 92-94\\ 20\text{X-3}, 131-135\\ 21\text{X-5}, 126-129\\ 22\text{X-1}, 108-110\\ 23\text{X-1}, 120-125\\ 24\text{X-3}, 85-90\\ 26\text{X-4}, 62-68\\ 26\text{X-2}, 81-85\\ 27\text{X-1}, 92-96\\ 28\text{X-2}, 10-15\\ 29\text{X-1}, 120-124\\ 30\text{X-1}, 75-79\\ 31\text{X-5}, 90-95\\ 32\text{X-1}, 32-37\\ 33\text{X-4}, 88-95\\ 36\text{X-1}, 93-97\\ 38\text{X-1}, 35-37\\ \end{array}$	0.8 4.3 4.8 <0.1	0.2 0.4 <0.1 0.8	2.0 0.4 1.2 1.2 1.3 2.6	4.3 4.4 1.5 2.9 <0.1 3.0 6.4 5.1 14.3	0.8 0.4 <0.1	1.2 0.6 3.1 1.1 1.6 3.0 2.4 16.3 3.4	2.6 3.3 1.5 24.8 22.5 6.1 9.1 19.9 7.7 14.3	<0.1	0.8 2.8 1.5 2.2 0.3	5.7 8.3 1.8 1.3 3.6 5.6 7.7 4.8 3.7 0.8 0.8 0.8 0.5	0.2	<0.1	2.2 0.6		0.8 <0.1 0.4
	middle Miocene	39X-1, 46-52 2R-3, 69-73 3R-3, 41-45, . 5R-2, 41-43 7R-3, 62-66 8R-2, 61-67 9R-3, 13-14 10R-4, 54-57	<0.1	0.2 2.2	2.2	5.9 4.8 2.2	0.2	1.5 0.7	1.5 2.5	1.1 : :	1.0						••••••

of rain forest taxa in locations having a higher rainfall than in regions that are drier today. Thus, the rain forest retracted from the drier inland regions progressively, toward the wetter coastal strip where rain forest is still found in favorable habitats.

The most striking difference between Site 765 and the eastern Australia late Cenozoic localities is the absence of any unequivocal rain forest. The absence of Araucariaceae is probably particularly significant, as it is indicative of drier kinds of rain forest. The lack of rain forest pollen in the assemblages does not mean that rain forest was totally absent from the region. There are small patches of deciduous vine forests within the northwest region today, but surface sampling shows that such small stands are palynologically invisible (Kershaw, 1973). This earlier retraction of moist rain forest from the northwest is in accord with the present rainfall gradient: it is much drier in the northwest than in the southeast of the continent. In common with the eastern Australian localities, however, Site 765 shows major changes at much the same time, particularly the development of widespread grasslands in the Pliocene/Pleistocene.

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Table 2 (continued).

æ	Age	Core, section, interval (cm)	Nematosphaeropsis? wrennii	Selenopemphix nephroides	Impagidinium sp. A	Multispinula quanta	Stelladinium reidii	Votadinium calvum	Count
Quaternary		1H-2, 142–144 1H-3, 80–82 3H-6, 37–43 4H-3, 60–65 5H-6, 63–65 6H-1, 69–75 7H-6, 56–60 8H-3, 4–6 9H-2, 100–107			0.9 2.5 <0.1	<0.1 0.4 0.5	· · · · ·	0.4	33 2 117 750 196 340 — 247
	Pliocene	10H-1, 123–127 11H-3, 38–42 12H-7, 26–30 13H-3, 78–83 14R-1, 4–6 14H-4, 36–42 15H-6, 28–33 16H-1, 70–74 17H-4, 111–115	*******	0.2					
Tertiary	late Miocene	18H-5, 48–54 19X-2, 92–94 20X-3, 131–135 21X-5, 126–129 22X-1, 108–110 23X-1, 120–125 24X-3, 85–90 26X-4, 62–68 26X-2, 81–85 27X-1, 92–96 28X-2, 10–15 29X-1, 120–124 30X-1, 75–79 31X-5, 90–95 32X-1, 32–37 33X-4, 88–95 36X-1, 93–97	·	化化化化化化化化化化化化化化				<i>Wotadinium calvum</i>	489 181 68 273 324 33 258 255 124 222 16 242 356 373 42 207 30 37
	middle Miocene	38x-1, 35-37 39x-1, 46-52 2R-3, 69-73 3R-3, 41-45 5R-2, 41-43 7R-3, 62-66 8R-2, 61-67 9R-3, 13-14 10R-4, 54-57			•	• • • • • • • •			205 436 47 3 23 42 7 7

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