



关于南雄盆地 K/T 界线地层 序列的几个问题

D. A. 拉塞尔

D. E. 拉塞尔

(加拿大自然博物馆研究部,渥太华) (法国国家自然历史博物馆,古生物研究所,巴黎)

A. R. 斯威特

(加拿大地质调查所沉积学和石油地质研究院,卡尔加里)

中国南部南雄盆地含 K/T 界线的陆相沉积是很宝贵的地史资料。因为迄今为止,除北美西部以外,含 K/T 界线的陆相露头研究得很少,赵资奎等(1991)提供了有关南雄盆地 K/T 界线的丰富资料。我们尝试着对其中一些资料作不同的解释,以鼓励在南雄工作的同行。

南雄地层的年代测定对研究该地的 K/T 界线至关重要。园圃组上段所含喷发玄武岩的平均年龄为 67.4ma (赵资奎等,1991),属于晚 Maestrichtian 期,大约与 31 正向磁极性带的顶部同时。如果 31N 带在该地全部保存的话,园圃组上段的沉积速率将为 70 m/ma (见表 I)。上覆坪岭组厚约 161m,赵资奎等(1991)认为其下段 33m 所含的正向磁极性带是 30N,如果该带在这里全部保存,这一段的沉积速率将是 19.3m/ma,这和加拿大西部含 K/T 界线地层的沉积速率接近。

赵资奎等(1991)认为坪岭组上段微量元素富集带的底界在 K/T 界线下 120m 处,其出现时间在白垩纪终结之前 30 万年,这样从该处到 K/T 界线间地层的沉积速率将是 400m/ma;如果坪岭组上段的反向磁极性带是 29R 的话,沉积速率也接近 300m/ma。这些速率很高,比北美东部快速沉降的三叠—侏罗纪裂谷中形成的纽瓦克群的沉积速率(250m/ma)还要高出许多,比下伏确定为 30N 的极性带的沉积速率则高出一个数量级还不止,这是否意味着坪岭组下段有缺失呢?如果把上述磁极性带与较老的磁极性带对比,则沉积速率的差别就会减小(表 II),但由此得到的园圃组上段的年龄要比从玄武岩推算出的年龄老 3.3ma。

脊椎动物化石对解决该地时间地层学或磁性地层学难题帮助不大。坪岭组中仅有一些爬行类化石残片、另有十二种蛋化石,按数量多少分成两类:出现较多的有四种,较少的有八种,后八种的延续时间比前四种短。

有证据表明蛋壳的病理特征和环境变化有关。在坪岭组顶界之下 100m 处蛋壳中微量元素的富集骤然达到顶峰。顶峰带中“*Macroolithis yaotunensis*”种内病态蛋壳占 75%。而顶峰带之下地层中病态蛋壳的背景值为 20%。比顶峰带高的层位中,病态蛋壳

的比例又减少;相应地,微量元素的富集(这种富集或许和附近富矿岩石的出露剥蚀有关)也降回到接近背景值。这样微量元素的富集和蛋壳病态都与中生代的最后绝灭无关。

同样,白垩纪地层顶界以下 51—66m 以及 79—106m 两段蛋壳中的 $\delta^{18}\text{O}$ 异常指示了一种极端干燥的气候条件。从坪岭组底部向上到“*Elongatolithus andrewsi*”最后出现处其蛋壳厚度趋于变薄,而该种蛋化石的最后出现正处于较早一个干燥层的峰值附近。这也表明物种的地区性消失是区域性环境异常造成的而非大绝灭的后果。

南雄盆地 K/T 界线上下地层是否连续? 赵资奎等(1991)没有提到白垩纪坪岭组和上覆古新世上湖组之间是否有缺异常。Mateer 和 Chen (1992) 则认为两组之间有缺失。上湖组之上浓山组的哺乳动物组合中含有 *Coryphodon* 和 *Prodinoceras*¹⁾。在北美这两个属出现在中晚古新世地层中。接近上湖组底部还有一个较小的哺乳动物组合,其中含有十七类动物(都是地方性属),以阶齿兽最有意义。这一组合不象是早古新世的(因为在中国还没有确切的早古新世哺乳动物群),鉴于在晚古新世从未见到过阶齿兽类,这个动物群只能归到中古新世。

李曼英(1989)描述的采自上湖组的一些孢粉类群和欧洲北美老第三纪的一些类型很接近。比较有意义的有 *Platycaryapollenites minutus*、*Juglanspollenites versus*、*Pterocaryapollenites stellatus* 和 *Tiliaepollenites microreticulatus*。它们的时代不大可能早于晚古新世。

上湖组的哺乳动物组合归在中古新世是最省事的,而孢粉组合最早只能是晚古新世的。这两种组合间的时代差别不难解释。上湖组共有 470—600m 厚,即使局部的沉积速率达到 100m/ma 这样的数量级或更高一些,上湖组的延续时间也占了古新世(延续 9.5 ma, 从 64.5ma 到 54ma)的很大一部分,哺乳动物集中在该组最下部分而孢粉组合穿越该组大部。即使没有更确切的生物地层学资料,也可以肯定古新世最早的几百万年在该地没有记录,该组中部被赵资奎等(1991)确定为“29N”和“28N”的两个正向磁极性带不可能老于 26N 和 25N。

赵资奎和他的同事们准确地揭示了南雄盆地 K/T 界线附近微量元素和同位素丰度的波动以及恐龙蛋壳的反常变异,我们期待着他们能在已有的基础上做出更引人入胜的成果。

(胡耀明摘译)

1) 原文有误,迄今为止南雄盆地浓山组并未发现这两类动物(译者注)。

THE END OF THE DINOSAURIAN ERA IN THE NANXIONG BASIN

Dale A. Russell

(Research Division, Canadian Museum of Nature, Ottawa)

Donald E. Russell

(Institut de Paléontologie, Muséum National d'Histoire Naturelle, Paris)

Arthur R. Sweet

(Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, Calgary)

Well exposed continental sections containing the Cretaceous-Paleocene transition have seldom been described outside of western North America. This circumstance, together with the wealth of data presented by Zhao and his associates (1991), underscores the importance of the record preserved in the Nanxiong Basin of Guangdong and Jiangxi provinces in southern China. We wish to suggest that some of this data is open to more than one interpretation, as well as to encourage our colleagues in their research on Cretaceous-Paleocene boundary events in the Nanxiong Basin.

The chronological framework of the Nanxiong sections is of major importance in understanding the local record of the Cretaceous-Tertiary transition. A basaltic lava flow near the top of Yuanpu Formation yielded dates averaging 67.4 ma (Zhao et al. 1991, p. 157), indicating a late Maestrichtian age and approximate contemporaneity with the end of polarity Chron 31N (Zhao et al. 1991, fig. 2; Harland et al. 1990, p. 157). If correctly identified, the duration and local thickness of the chron suggest a depositional rate for the upper part of the Yuanpu of 70 m/ma (Table 1). A measured section of the overlying Pingling Formation is 161 m thick, the basal 33 m of which contains a polarity chron identified as 30N (Zhao et al. 1990, fig. 3, p. 15). If all of the chron were present, a depositional rate of 19.3 m/ma would be indicated (Table 1). This rate is similar to depositional rates across the Cretaceous-Tertiary boundary in western Canada (compare thicknesses of chrons in Lerbekmo and Coulter 1984 with durations in Harland et al. 1990, p. 157).

Table 1: Identification and local thicknesses of paleomagnetic chrons in the Nanxiong Basin Chron durations and age of Cretaceous-Tertiary boundary are after Zhao et al. (1991, p. 14) and Harland et al. (1990, p. 157).

	chron	thickness	duration	rate
Shanghu Formation:				
Interval 390—415m	28N	25m	0.84ma	29.8m/ma
Interval 259—390m	28R	131m	0.38ma	344.7m/ma
Interval 236—259m	29N	23m	0.69ma	33.3m/ma
Interval 161—236m	29R	75m	0.15ma	500.0m/ma

	chron	thickness	duration	rate
Pingling Formation:				
Interval 33—161m	29R	128m	0.43ma	297.8m/ma
Interval 0—33m	30N	33m	1.71ma	19.3m/ma
Yuanpu Formation:				
Interval 109—172m	31N	63m	0.90ma	70.0m/ma

Zhao et al. (1991, p. 20) postulate that the base of a zone of trace element enhancement in the upper part of the Pingling Formation (120 m below the local Cretaceous-Tertiary boundary) predated the end of the Cretaceous by 300, 000 years. A sedimentation rate of 400 m/ma is thereby implied. If Chron 29R is correctly identified in the upper portion of formation, a rate of nearly 300 m/ma is indicated (Table 2). These are very high depositional rates, exceeding those in the rapidly subsiding Triassic-Jurassic rift valleys of the Newark Group in eastern North America (about 250 m/ma, see Olsen 1986). They are also more than an order of magnitude greater than that implied by the underlying chron identified as 30N; does a hiatus occur near the base of the Pingling Formation? A correlation with older chrons reduces the apparent variation in sedimentation rates (Table 2), but implies an age for the upper part of the Yuanpu Formation which is about 3.3 ma older than the average of the dates from the basalt flow (if they are accurate).

Table 2: As for Table 1, with alternative chron identifications (see text).

Shanghu Formation:				
Interval 390—415m	25N	25m	0.61ma	41.0m/ma
Interval 259—390m	25R	131m	2.14ma	61.2m/ma
Interval 236—259m	26N	23m	0.55ma	41.8m/ma
Interval 161—236m	26R	75 + m	2.32ma	32.3 + m/ma
Pingling Formation:				
Interval 33—161m	31R	128 + m	2.01ma	63.7 + m/ma
Interval 0—33m	32.1N	33m	0.28ma	117.9m/ma
Yuanpu Formation:				
Interval 109—172m	32.2N	63m	1.66ma	38.0m/ma

The fossil vertebrate record is inadequate to resolve alternative chrono- and magnetostratigraphic interpretations. Rare skeletal remains in the Pingling Formation indicate the presence of lizards, large terrestrial turtles, small theropods, tyrannosaurids, therizinosaurids, dicraeosaurids, small ornithopods and hadrosaurids (Young 1965, Yeh 1966, Dong 1979, Young and Chow 1982; for horizon of occurrence of some specimens see Mateer and Chen 1992). The 12 egg taxa occurring in the unit are divided into two groups according to frequency of occurrence (over 20, 000 stratigraphically documented shell fragments were collected): 4 species are represented by an average of about 3,860 fragments per species, and 8 species by an average of about 570 fragments per species (Zhao et al. 1991, pp. 15, 16). None of the poorly-represented species have stratigraphic ranges as extensive as those of the 4 well-represented species (Zhao et al. 1991, fig. 2), suggesting that sample size may be a factor in their apparently more restricted stratigraphic distribution (cf. Koch 1991).

There are indications that egg-shell pathology may be associated with evidence of environmental changes. Concentrations of several trace elements (Ni, Co, Pb, Cu, Mn; see Zhao et al. 1991, fig. 4) abruptly peak in eggshells approximately 100 meters below the top of the Pingling Formation. Within the zone of trace element enrichment, micropathologic shells belonging to the common species "*Macroolithis yaotunensis*" increase to a frequency of 75% from background levels of 20% below the zone (Zhao et al. 1991, p. 17). Higher in the formation trace element concentrations (perhaps due to the transient exposure through erosion of a nearby metal-rich source rock adjacent to the fault basin), paralleling a reduction in the incidence of egg shell pathology, return to near-background levels. Thus both could be unrelated to the terminal Mesozoic extinctions.

Similarly, oxygen 18 anomalies in eggshells (Zhao et al. 1991, p. 19, fig. 3) indicate the existence of unusually arid conditions during the deposition of strata occurring 51—66 and 79—106 meters below the top of the Cretaceous sequence. The thickness of relatively abundant "*Elongatolithus andrewsi*" shells decreases from the bottom of the Pingling Formation to the point where these shells disappear from the record near the climax of the lower arid interval (Zhao et al. 1991, fig. 3), and could reflect a local extermination due to a local environmental excursion rather than the onset of a mass extinction.

Was deposition continuous through the Cretaceous-Tertiary boundary in the Nanxiong Basin? Zhao et al. (1991) make no mention of an iridium anomaly between the Cretaceous Pingling Formation and the overlying Paleocene Shanghu Formation, and Mateer and Chen (1992) suggest that a hiatus may occur between the two units. The Shanghu is overlain by the Nongshan Formation, which has produced a mammalian assemblage containing *Coryphodon* and *Prodinoceras*. These two genera occur in the middle and late Paleocene of North America (Russell and Zhai 1987). A small mammalian assemblage also occurs near the base of the Shanghu Formation, which contains only 17 taxa (all of which are endemic on a generic level) and is dominated by the remains of bimalambdid pantodonts (Russell and Zhai 1987, p. 33 fig. 8). This assemblage cannot be shown to be of early Paleocene age (early Paleocene mammalian assemblages have not yet been identified in any of the sedimentary basins of China), and is attributed to the middle Paleocene for the reason that bimalambdids are unknown in strata regarded as being of late Paleocene age.

Some of the pollen taxa illustrated by Li (1989) from the Shanghu Formation are closely related to forms occurring in the Paleogene of North America and Europe, and are of particular biostratigraphic significance: *Platycaryapollenites minutus* Ke et Shi (Li 1989, pl. 1 figs. 26, 27 as *Platycaryapollenites minutus*), *Juglanspollenites versus* Raatz (Li 1989, pl. 2 fig. 25), *Pterocaryapollenites stellatus* (R. Pot.) Raatz (Li 1989, pl. 3 figs. 1—3), and *Tiliaepollenites microreticulatus* (Mai.) Ke et Shi (Li 1989, pl. 3 figs. 15—17).

The first occurrence of *Platycarya platycaryoides* was advanced as a means of recognizing the base of the Eocene in the western interior of North America by Wing (1984), who placed the Paleocene-Eocene boundary within the Wasatchian Land Mammal Age. Rare occurrences of platycaryoid pollen have also been reported from the late Paleocene of the southeastern United States (Frederiksen and Christopher 1978), preceding the more frequent occurrences in the Eocene of North America (Manchester 1987). These occurrences are supported by well documented occurrences of platycaryoid pollen in the late Paleocene of Europe (Manchester 1987), including the Thanetian of Menat, France (Kedves 1982).

Taxa referable to the Juglandaceae, including both *Juglans* and *Pterocarya*, also originate

in the Paleogene (Manchester 1987, table 6). Of the above genera, *Juglans* has the more restricted range. The earliest known *Juglans* fruit is from the middle Eocene of Oregon (Manchester 1987), which approximately correlates with the earliest record of *Juglans* pollen from the middle Eocene (Rouse 1977). However, because the degree of heteropolarity in the distribution of the pores in the specimen illustrated as *Juglanspollenites versus* by Li (1989, pl. 2 fig. 25) and other pollen placed in *Juglanspollenites* (Li 1989, pl. 3 figs. 5, 8, 9, 13) is not sufficiently clear, it is impossible to infer with certainty an Eocene age for the source strata.

Pollen of the Tiliaceae is first recorded from the middle Paleocene of North America (Nichols and Ott 1978, Demchuck 1990). The earliest species recorded (*Tilia danei* Anderson as in Demchuck) is microreticulate. Higher in the Paleocene and into the Eocene the reticulation becomes coarser, and coarsely reticulate species are considered diagnostic of Eocene time by Rouse (1977). The size of the reticulation on specimens illustrated as *Tiliaepollenites microreticulatus* by Li (1989) is comparable to that on specimens from the Thanetian of Menat (Kedves 1982, pl. 13 figs. 1—12, included in the tiliaceoid form genus *Intratiporopollenites*) and hence Li's specimens would be compatible with an age as old as late Paleocene.

The mammalian assemblage from the Shangu Formation is most easily interpreted as being of middle Paleocene age (D.E.R.), while the palynofloral assemblage is at least as young as the late Paleocene (A.R.S.), an age difference that could well be more apparent than real. In any case, the Shangu Formation is 470—600 m thick, and even if local sedimentation rates were of the order of 100 m/ma or greater, the unit would contain a significant fraction of Paleocene time (which spans 9.5 ma, from 64.5 to 54 ma, cf. Izett et al. 1991, Odin and Kreuzer 1988, Odin and Odin 1990). As noted above, mammalian localities are clustered near the base of the formation and pollen localities are presumably distributed through most of the unit. Even in the absence of more precise biostratigraphic information, it would appear that several millions of years of the earliest part of the Paleocene record is absent, and it is unlikely that the chrons identified by Zhao et al. (1991) near the middle of the formation as "29N" and "28N" are older than 26N and 25N (see Table 2).

Zhao and his colleagues have documented the presence of a fascinating complex of fluctuations in trace-element and isotopic abundances, and a truly exceptional variety of dinosaur eggs within the Nanxiong Basin. We look forward to a continuation of the research they have established on such fascinating themes.

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