

**Subdivision and faunal characteristics of the Cretaceous-Tertiary
Lufozhai Group in the Pingling cross-section of the Nanxiong Basin**

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Journal of Stratigraphy
Volume 8, April
1984
PP. 239-254

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October, 2000

Introduction

The Nanxiong Basin is significant regarding the study of Chinese Cretaceous-Tertiary terrestrial sediments and their associated faunas. After the 1976 "South China Cretaceous Tertiary Red Beds Field Conference," formations within the Nanxiong Basin were recognized as typifying the Chinese terrestrial Paleocene, with the Shanghu Fm. designated Lower and Middle Paleocene, and Nongshan Fm. as Upper Paleocene. The Pingling-Zhenxian cross-section has been regarded the type section for the Lufozhai Group because of its distinct exposure and abundant paleontological data. In 1978 this section was measured by the author and 376 samples were taken for microfossil analysis. Among these samples, 86 produced ostracods and 34 produced charophytes. Analysis of the lithologic and paleontological data resulted in the recognition of seven members and three formations within the Lufozhai Group. The Pingling Mem. of the Shanghu Fm. is recognized as Late Cretaceous, The Xiahui and Nilong members are recognized as Early and Middle Paleocene respectively. The entire Nongshan Fm. is recognized as Late Paleocene and the entire Gucheng Fm. is recognized as Eocene as illustrated in Table 1.

Table 1. Subdivision of the Lufozhai Group at the Pingling-Zhenxian cross-section.

Lofuozhai Group	{	Gucheng Formation	{	Zhenxianyan Member	} Eocene
			{	Maojiwan Member	
		Nongshan Formation	{	Tatang Member	} Late Paleocene
	{	Zhuguikeng Member			
		Shanghu Formation	{	Nilongxiang Member	Middle Paleocene
			{	Xiahui Member	Lower Paleocene
			{	Pingling Member	Upper Cretaceous

Cross-sections

The Pingling section is located in the northeast portion of the Nanxiong Basin west of Datang. The section initiates at the village of Shangpingling, traverses Nilongxiang, Gucheng, and terminates south of Zhenxianyan (Fig. 1). This section contains the type localities for the Nongshan Fm. (Zhuguikeng and Datang mems.) and the Gucheng Fm. (Maojiwan and Zhanxianyan mems.). It also represents the best exposures of the Shanghu Fm. containing the most abundant specimens of micro-invertebrates, and thus represents a relatively well studied cross-section. The stratigraphic sequence (in meters) is as follows.

Lower Eocene Gucheng Fm.

Zhenxian Member

77. Gray-yellow, gray-green silty mudstone, representing the synclinal axis. Top unobservable.....	4.37
76. Tan silty mudstone.....	14.75
75. Tan silty mudstone.....	7.8
74. Obscured.....	52.62
73. Dark tan silty mudstone	4.00
72. Purple-tan silty mudstone interbedded with gray-green and gray-yellow units	1.20
71. Dark tan silty mudstone capped with light gray-tan calcareous siltstone	3.87

70. Gray-black and dark tan silty mudstone.....	2.05
69. Dark tan silty mudstone interbedded with gray-green and gray-yellow units	23.70
68. Dark tan silty mudstone	10.5
67. Tan, gray-yellow, and gray-green silty mudstone with a base of a .8 m thick siltstone	6.56

Maojiwan Member

66. Tan-red calcareous mudstone with the middle and lower section interbedded with light gray mudstone, producing abundant ostracods including <i>Cyprois buxinensis</i> , and <i>Candona</i> sp.....	13.0
65. Tan-red mudstone with the middle and lower section interbedded with gray-black silty mudstones and argillaceous siltstones producing a pollen complex (Np345) with ferns constituting 34.67%, dominated by the genus <i>Pterisporites</i> at 26%, predominantly with <i>P. undulatus</i> , <i>P. zonatus</i> , <i>P. tuberosus</i> , and <i>P. trizonatus</i> . Other genera of ferns and NAP constitute under 2%. Angiosperms constitute 9% with the species <i>Classopollis annulatus</i> at 2.34% and <i>Ephedripites (Distachyapites) fushenensis</i> at 1.34%. Gymnosperms constitute 59.33% of the complex, dominated by tricolpate and tricolporate forms, among which are <i>Ulmipolleites minor</i> (2%), <i>U. tricostatus</i> (1.34%), <i>Plicapollus granulatus</i> (2.67%), <i>Tricopollenites minutus</i> (6.67%), <i>Quercoidites micohenrici</i> (4.67%), <i>Q. minutus</i> (2%), <i>Cupuliferoipollenites pusillus</i> (4%), <i>C. cingulum</i> (2%), <i>Pentapollenites dungtaiensis</i> (1%), and <i>Rutaceoipollis ovatus</i> (2.33%).....	12.00
64. Tan-red siltstone interbedded with fine banded sandstones, with midsection interbedded with gray-black mudstones.....	27.70
63, 62. Obscured.	53.40
61. Tan-red mudstone interbedded gray-black mudstone and thinly laminated fine sandstones.....	21.16
60. Uppermost and basal sections as light gray, gray-black mudstones interbedded with calcareous units. Midsection as tan-red mudstone	11.10
59. Tan-red mudstone interbedded with thinly laminated calcareous siltstones. Midsection interbedded with a 2 m thick black mudstone	10.94
58. Tan-red mudstone interbedded with calcareous siltstone bands. Middle and basal sections interbedded with three 1 m thick units of gray-black mudstones producing the ostracod <i>Cyprois buxinensis</i> (Np 325)	15.07
57. Tan-red and gray-black interfingering mudstones interbedded with thinly laminated calcareous siltstone	20.80.
56. Tan-red and gray-black mudstones interbedded with thinly laminated calcareous fine sandstones and siltstone with a small quantity of pollen and spores (Np306): 3 grains of fern spores, two grains of angiosperm pollen, and 43 grains of gymnosperm pollen represented by <i>Plicapollis granulatus</i> (4), <i>Ulmipollenites minor</i> (3), <i>Quercoidites</i> (3), <i>Q. microhenrici</i> (4), <i>Tricopollenites minutus</i> (4), <i>T. sp.</i> (11), <i>Cupuliferoipollenites pusellus</i> (3), and <i>Pentapollenites duntaiensis</i> (3).....	9.30
55. Tan-red mudstone interbedded with siltstones bands.....	22.42
54., 53. Tan-red and gray-black interfingering mudstones interbedded with calcareous siltstone bands and containing the gastropod <i>Polycirsas gracilicostata</i> (Np275, 277).....	54.40

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Upper Paleocene Nongshan Fm.

Datang Member

52. Dark tan silty mudstone interfingering with light tan calcareous siltstone with the top unit as siltstone and producing the ostracod <i>Cyprois buxinensis</i> (Np272)	7.72
51. Light gray-tan calcareous siltstone partially as rudaceous coarse	

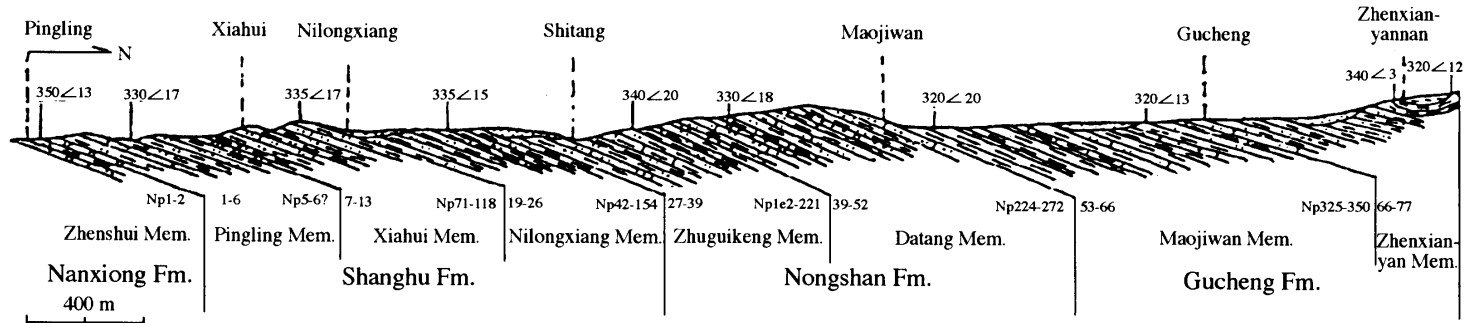


Figure 1. Cross-section of the Luofozhai Group from Pingling to Zhenxianyan.

Table 2. Correlation chart of the Luofozhai Group to related sediments.

Region		Division																			
		Nanxiong Basin				Sanshui, Guang-dong	Heng-yang, Hunan	Dong-tinghu, Henan	NW Jiangnan Plane	Hepu, Guangxi	Western Yunnan	Sichuan	Jiangxi	Jiangsu	Europe	North America	Mongolia				
Cretaceous	Upper	Paleocene	Early	Middle	Late	Eocene	Early	Gucheng Fm.	Zhenxianyan Mem.	Buxin Fm.	Xialiusi Fm.	Yuanjiang Fm.	Fang-jiahe Fm.	Shangyang Fm.	Guolang Fm.	Mingshan Group	Chijiang Fm.	Funing Group	Lutetia Cuisian	Bridgerian	?
									Maojiwan Mem.										Ypresian (Sparnacian)	Wasatchian	
Cretaceous	Upper	Paleocene	Early	Middle	Late	Eocene	Early	Gucheng Fm.	Datang Mem.	Buxin Fm.	Xialiusi Fm.	Yuanjiang Fm.	Fang-jiahe Fm.	Shangyang Fm.	Guolang Fm.	Mingshan Group	Chijiang Fm.	Funing Group	Thanetian	Tiffanian	White beds (Gashato)
									Zhuguikeng Mem.										Member III	Member II	Member I
Cretaceous	Upper	Paleocene	Early	Middle	Late	Eocene	Early	Gucheng Fm.	Nilongxia Mem.	Buxin Fm.	Xialiusi Fm.	Yuanjiang Fm.	Fang-jiahe Fm.	Shangyang Fm.	Guolang Fm.	Mingshan Group	Chijiang Fm.	Funing Group	Montian	Torrejonian Dragonian Puercan	?
									Xiahui Mem.										Member II	Member I	Danian Maestrichtian
Cretaceous	Upper	Paleocene	Early	Middle	Late	Eocene	Early	Gucheng Fm.	Pingling Mem.	Buxin Fm.	Xialiusi Fm.	Yuanjiang Fm.	Fang-jiahe Fm.	Shangyang Fm.	Guolang Fm.	Mingshan Group	Chijiang Fm.	Funing Group	Danian Maestrichtian	Lancian	Upper Nemegt beds
									Dabishan Fm.										Member II	Member I	Danian Maestrichtian

sandstones.....	8.99
50. Dark tan silty mudstone interbedded with calcareous siltstone, containing the ostracod <i>Cyprois buxinensis</i> and <i>C. sp.</i> (Np270).....	25.69
49-48. Dark tan silty mudstone interfingering with light tan calcareous siltstone, approaching the top, the unit becomes interbedded with marls, at the top and base as siltstone and produces the ostracods <i>Sinocypris subfuningensis</i> , and <i>Limnocythere sp.</i> (NP264)..	21.40
47. Dark tan silty mudstone interbedded with gray-green limestone, base interbedded with sandy conglomerate lenses and produces the ostracod <i>Cyprois buxinensis</i> and gastropod <i>Polycirsas gracilicostata</i> (Np256, 261).....	38.10
46. Dark tan silty mudstone interbedded with calcareous siltstone	14.80
45. Cyclothems of predominantly siltstone but with light gray-tan fine gravel and coarse sands, light tan calcareous siltstone, and dark tan silty mudstone.	
44. Dark tan silty mudstone interbedded with gray-green marls, producing the ostracods <i>Cyprois buxinensis</i> and <i>Candona resupina</i> (Np245, 247), the charophytes <i>Neochara squalida</i> , <i>N. huananensis</i> , <i>N. xinzhuangensis</i> , <i>Peckichara longa</i> , <i>P. subspherica</i> , <i>Rhabdochara jiangduensis</i> , <i>Rh. changzhouensis</i> , <i>Rh. changzhouensis</i> , <i>Raskyaechara xinghuaensis</i> , <i>R. shishanensis</i> , and <i>Harrisichara poculiformis</i> (Np247).....	23.30
43. Dark tan silty mudstone interfingering with light tan calcareous siltstone, producing the ostracod <i>Eucypris dongguanensis</i> (Np240)	7.35
42. Dark tan silty mudstone interbedded with thinly laminated or banded sandy conglomerates and coarse sandstone producing the ostracods <i>Eucypris dongguanensis</i> , and <i>Sinosypris subfuningensis</i> (Np234, 239)	13.08
41. Dark tan silty mudstone with calcareous concretions interbedded with thinly laminated bands of calcareous siltstone, producing the ostracods <i>Eucypris sanshuiensis</i> and <i>E. dongguanensis</i> (Np230, 232).....	16.95
40. Dark tan silty mudstone with abundant calcareous concretions interbedded with thinly laminated calcareous siltstone, producing the ostracods <i>Eucypris dongguanensis</i> , <i>E. ? sanshuiensis</i> , <i>Cypris ? pyriformis</i> , <i>Cyprois robusta</i> , and <i>Candona resupina</i> (Np224, 226, 228, 229); charophytes include <i>Neochara squalida</i> , <i>Peckichara subspherica</i> , <i>P. zuomalingensis</i> , <i>P. coronata</i> , <i>Sinochara rudongensis</i> , <i>Charites minutissima</i> , <i>Gobichara deserta</i> , <i>Rhabdochara changzhouensis</i> , <i>Obtusochara brevicylindrica</i> , <i>Grovesichara changzhouensis</i> , <i>G. kielani</i> , <i>G. stepanovi</i> , <i>Stephanochara brevivalis</i> , <i>St. kiangsuensis</i> , <i>St. conspicua</i> , <i>St. sp.</i> , <i>Sphaerochara parvula</i> , <i>Croftiella humilis</i> , <i>Harrisichara yunlongensis</i> , <i>Grambastichara ampliovata</i> , <i>Gyrogona huajiazhuangensis</i> , and <i>G. cataneiformis</i> (Np224, 228).....	24.50
39-2. Light tan calcareous sit to find sand interbedded with coarse sandstone bands.....	2.00

Zhuguikeng Member

39-1. Tan silty mudstone producing the ostracods <i>Eucypris sanshuiensis</i> , <i>E. squarrosa</i> , <i>Sinocypris excelsa</i> , <i>S. subfuningensis</i> , <i>Ilyocypris macilenta</i> , <i>Parailyocypris changzhouensis</i> , <i>Cypris pyriformis</i> , <i>Cyprois buxinensis</i> , <i>Candona resupina</i> , and <i>Limnocythere hongganensis</i> (Np217-221)	16.40
38. Tan silty mudstone with middle and upper sections interbedded with gray-green marls. Sediments are stromatolitic with worm burrows, gastropods, and turtle fragments. Gastropods include <i>Polycirsas gracincostata</i> and <i>Opeas guangdongensis</i> (Np207, 208, 209, 212, 213, 215). Ostracods include <i>Eucypris sanshuiensis</i> , <i>E. dongguanensis</i> , <i>E. squarrosa</i> , <i>Sinocypris excelsa</i> , <i>S. subfuningensis</i> , <i>Ilyocypris macilenta</i> , <i>Parailyocypris changzhouensis</i> , <i>Metacypris biromis</i> , <i>Limnocythere honggangensis</i> , <i>Cyclocypris mobilis</i> , and <i>Candona resupina</i> (Np207, 208, 209, 212, 214, 214). Charophytes include <i>Grovesichara kielani</i> , <i>G. stepanovi</i> , <i>Gobichara deserta</i> , <i>Charites minutissima</i> , <i>Rhabdochara jiangduensis</i> , <i>Rh. buxinensis</i> , <i>Rh. changzhouensis</i> , <i>Stephanochara kiangsuensis</i> , <i>Peckichara zuomalingensis</i> , <i>P. longa</i> , <i>P. subspherica</i> , <i>P. varians</i> , <i>Sinochara guangdongensis</i> , <i>S. rudongensis</i> , <i>S. dongtaiensis</i> , <i>Neochara huananensis</i> , <i>N. squalida</i> , <i>N. magna</i> , <i>Gyrogona huajiazhuangensis</i> , <i>Grambastichara ampliovata</i> , <i>Harrisichara yunlongensis</i> ,	

<i>H. poculisformis</i> , <i>Croftiella humilis</i> , <i>C. steniformis</i> , <i>Turbochara aechma</i> , <i>T. specialis</i> , and <i>Raskyaechara shishanensis</i> (Np207, 209, 214).....	13.90
37. Tan silty mudstone with top as .4 m thick gray-green marl that produces the ostracod <i>Sinocypris?</i> sp. (Np205).....	3.34
36., 35. Tan silty mudstone with top as .4 m thick gray-green marl, producing the ostracods <i>Sinosypris excelsa</i> , and <i>Limnocythere hongangensis</i> (Np204).....	10.89
34. Tan silty mudstone interbedded with three units (.8, 1.5, and .8 m thick) gray-green calcareous mudstone, producing the ostracods <i>Eucypris sanshuiensis</i> , <i>Sinocypris excelsa</i> , and <i>Parailocypris changzhouensis</i> (Np189, 191, 193, 195, 199). Charophytes include <i>Grovesichara changzhuensis</i> , <i>Neochara huananensis</i> , <i>N. squalida</i> , <i>N. sinuolata</i> , <i>N. magna</i> , <i>N. xinzhuangensis</i> , <i>Harrisichara yunlongensis</i> , <i>H. poculiformis</i> , <i>Croftiella humilis</i> , <i>C. steniformis</i> , <i>Peckichara zuomalingensis</i> , <i>P. longa</i> , <i>P. subspherica</i> , <i>P. minoriquadrata</i> , <i>P. varians</i> , <i>Stephanochara breviovialis</i> , <i>St. huangjinensis</i> , <i>St. fortis.</i> , <i>St. funingensis</i> , <i>St. kiangsuensis</i> , <i>St. hukouensis</i> , <i>St. xibucunensis</i> , <i>Rhabdochara jiangduensis</i> , <i>Rh. buxinensis</i> , <i>Rh. contracta</i> , <i>Rh. luofuzaensis</i> , <i>Rh. changshouensis</i> , <i>Rh. kisgyonensis</i> , <i>Gobichara deserta</i> , <i>G. lauta</i> , <i>G. granda</i> , <i>Maedlerisphaera minleensis</i> , <i>Charites fusca</i> , <i>Turbochara aechma</i> , and <i>Sinochara rudongensis</i> (Np191, 193, 195, 196, 199)	15.44
33-32. Gray-tan, light red-tan silty mudstone with abundant calcareous concretions. Lower section is interbedded with gray-green marls and partial fine conglomerate lenses are present. Produces the ostracods <i>Eucypris</i> sp. and <i>Sinocypris excelsa</i> (Np182, 185).....	19.70
31. Purple-gray silty mudstone with bands of gray-green and gray-tan	2.00
30. Red-tan silty mudstone with gray-green mottling.....	4.03
29., 28. Dark tan with gray-green mottled siltstone and gray-green calcareous siltstone	
27. Obscured.....	18.13

Upper Cretaceous to Middle, Lower Paleocene Shanghu Formation.

Middle Paleocene Nilongxiang Member

26. Dark tan silty mudstone with upper section obscured	25.00
25. Dark tan silty mudstone	20.20
24. Dark tan silty mudstone producing the ostracods <i>Eucypris sanshuiensis</i> , <i>E. sp.</i> and <i>Ilyocypris macilenta</i> (Np153, 154).....	24.20
23. Dark tan mudstone interbedded with two units of calcareous mudstone, producing the ostracods <i>Eucypris sanshuiensis</i> , <i>E. squarrosa</i> , <i>Ilyocypris macilenta</i> , <i>Parailocypris changzhouensis</i> , <i>Cypris robusta</i> , <i>Cypris pyriformis</i> , <i>Metacypris biformis</i> , gastropod and charophyte fragments (Np142-146, 149).....	18.40
22. Dark tan silty mudstone containing gastropod fragments	8.80
21. Dark tan silty mudstone	21.86
20. Obscured, but in the vicinity there is a dark tan silty mudstone	23.00
19. Obscured.....	21.80

Lower Paleocene Xiahui Member

13. Dark tan silty mudstone with calcareous concretions, producing the ostracods <i>Eucypris cf. sanshuiensis</i> , and <i>Candona (Candoniella) postrotunda</i> (Np118, 119).....	11.67
12. Dark tan silty mudstone in the upper section containing calcareous concretions and top (.8 m) as tan calcareous siltstone, producing the ostracods <i>Eucypris cf. sanshuiensis</i> , and <i>Candona (Candoniella) postrotunda</i> (Np113, 114, 115).....	21.50
11. Dark tan silty mudstone interbedded with gray-green calcareous coarse sandstones and light gray-tan siltstone bands, producing the ostracods <i>Eucypris cf. sanshuiensis</i> , <i>Ilyocypris subhuangqiaoensis</i> , and <i>Candona (Candoniella) postrotunda</i> (Np107-111, 113, 114). Charophytes are represented by <i>Obtusochara lanpingensis</i> (Np108), and gastropods by <i>Ammicola datangensis</i> (Np111)	25.00

10. Dark tan silty mudstone with top as 1.5 m thick light colored calcareous siltstone producing the ostracods *Eucypris* cf. *sanshuiensis*, *E. squarrosa*, *Ilyocypris subhuangqiaoensis*, *Cyprois? guangzhouensis*, *Candona (Candoniella) postrotunda*, and *Limnocythere nemegtensis* (Np99, 100, 102, 103, 105). Charophytes include *Charites fusca*, *Gobichara* cf. *lauta*, *Rhabdochara jiangduensis*, *Rh. changzhouensis*, *Rh. cf. buxinensis*, *Rh. contracta*, *Groveschara kielani*, *Stephanochara brevivalis*, *St. huangjinensis*, *St. cuneiformis*, *Peckichara zuomalingensis*, *P. subspherica*, *Sinochara guangdongensis*, *S. caopiensis*, *Neochara squalida*, *Gyrogona huajiazhuangensis*, *G. supracompressa*, *G. cataneiformis*, *Grambastichara ampliovata*, and *Croftiella humilis* (Np102, 105). 11.00
9. Dark tan silty mudstone, the top of which is a one m thick light colored calcareous siltstone producing the ostracod *Eucypris* cf. *sanshuiensis*..... 21.35
8. Dark tan silty mudstone with ginger-shaped calcareous concretions and lower section interbedded with light colored calcareous siltstone bands, producing the ostracods *Eucypris* cf. *sanshuiensis*, and *Candona (Candoniella) postrotunda* (Np80) and the charophyte *Obtusochara? lapingensis* (Np82) 22.60
7. Dark tan silty mudstone containing ginger-shaped calcareous concretions, top as gray-tan calcareous siltstone (1.2 m) and base as (1.1 m) calcareous conglomerate, producing the ostracods *Eucypris* cf. *sanshuiensis*, *Ilyocypris subhuangqiaoensis*, *Candona (Candoniella) postrotunda*, and *Limnocythere nemegtensis* (Np71, 72). Charophytes include *Charites guanpingensis*, *Nemegtichara prima*, *Obtusochara? brevicylindrica*, and *O. lanpingensis* (Np71) 11.10

Upper Cretaceous Pingling Member

6. Dark tan silty mudstone interbedded with two units of gray-green calcareous siltstone with abundant ginger-shaped concretions, producing the ostracod *Eucypris* cf. *sanshuiensis* (Np57, 58, 63, 66, 67) and the charophytes *Charites hengjiangensis*, *Obtusochara brevicylindrica*, *Hornichara dalangshanensis*, *Nemegtichara prima*, *N. quadrata*, *Rhabdochara* cf. *buxinensis*, and *?Gyrongonaqianjiangica* (Np57, 61, 66) 22.40
5. Dark tan silty mudstone with abundant ginger-shaped calcareous concretions with top as light tan calcareous siltstone, producing the ostracods *Eucypris* cf. *sanshuiensis*, *Candona (Candoniella) postrotunda* (Np52, 53) and the charophytes *Charites guanpingensis*, *Ch. hengjiangensis*, *Rhabdochara jiangduensis*, *Rh. cf. buxinensis*, *Obtusochara brevicylindrica*, *O. lapingensis*, *O. ovalis*, *Hornichara dalangshanensis*, and *Nemegtichara quadrata* (Np52, 53) 15.65
4. Upper section as tan silty mudstone, lower section as dark tan silty mudstone with abundant ginger-shaped concretions and producing the ostracods *Porpocypris sphaeroidalis*, *Quadracypris dalangshanensis*, *Ilyocypris subhuangqiaoensis*, *Parailocypris taizhouensis*, *Cypridea xindianensis*, *C. (Pseudocypridina) gigantea*, *Cyprois guangzhouensis*, *Candona (Candoniella) postrotunda*, *C. (C.) porrecta*, *Eucypris* cf. *sanshuiensis*, and *E. pinglingensis* Zhang sp. nov. (Np35, 43, 46, 48, 49, 50). Charophytes include *Charites guanpingensis*, *Ch. hengjiangensis*, *Ch. minutissima*, *GBobichara deserta*, *Rhabdochara jiangduensis*, *Rh. cf. buxinensis*, *Grambastichara ampliovata*, *Grovesichara kielani*, and *Nemegtichara prima* 14.30
3. Dark tan silty mudstone with abundant calcareous ginger-shaped concretions 1-3 cm in size. Top as light gray-tan argillaceous sandstone containing the ostracods *Porpocypris sphaeroidalis*, *Quadracypris dalangshanensis*, and *Eucypris* cf. *sanshuiensis* (Np27, 28, 32). Charophytes are represented by *Obtusochara? sp.* (Np32)..... 10.08
2. Dark tan silty mudstone with abundant calcareous concretions and top as variegated calcareous sandstone producing the ostracods *Porpocypris sphaeroidalis*, *Quadracypris dalangshanensis*, *Eucypris pinlingensis* Zhang sp. nov., *Cyclocypris minuta*, and *Candona (Candoniella) porrecta* (Np24, 25, 26). Charophytes are represented by *Grovesichara changzhouensis* (Np26), and gastropods are represented by *Parateinostoma? turriculata* (Np26)..... 18.90
1. Tan silty mudstone abundant in gray-green calcareous concretions, top as gray-tan sandstone, base as tan conglomerate that is discontinuous laterally and is composed predominantly

of 2-4 mm diameter quartz clasts. Extremely close to the base is the fossil mammal belonging to the Anagalidae*. Ostracods include *Porpocypris orbiculata*, *Quadracypris dalangshanensis*, *Ilyocypris subhuangqiaoensis*, *Parailocypris? taizhouensis*, *Candona (Candoniella) porrecta*, *C. (C.) postrotunda*, *Eucypris pinlingensis* Zhang sp. nov., *Cyclocypris minuta*, *Cypridea xindianensis*, *C. nanxiongensis*, *C. elongata*, *C. diplomoda*, and *Limnocythere nemegtensis* (Np5, 7, 8, NpA). Charophytes include *Charites guanpingensis*, *Obtusochara eulmina*, *O. brevicylindrica*, and *Grovesichara changzhouensis* (Np7).

-----Conformable contact-----

Upper Cretaceous Zhenshui Member

Gray-tan poorly sorted sandy conglomerate interfingering with differentially thick tan-red silty mudstones which are abundant in calcareous concretions and contain dinosaur eggs in addition to the ostracods *Cypridea* sp., *C. (Pseudocypridina) gigantia*, *Cristocypridea* sp., *Quadracypris? favosa*, *Cyprois guanzhouensis*, *Candona (Candoniella) porrecta*, *C. (C.) postrotunda*, *Zixiphocypris? sp.*, and *Limnocythere* sp. (Np1, 2, 4). Charophytes include *Maedlerisphaera sanshuiensis*, *M. minuscula*, *Charites guanpingensis*, *Ch. hengjiangensis*, *Gobichara nigra*, *Peckichara lefeldi*, *Rhabdochara jiangduensis*, *Rh. cf. buxinensis*, *Obtusochara culmina*, *O. brevicylindrica*, and *Grovesichara changzhouensis*.

Stratigraphic subdivision

A relatively detailed study has been conducted on the Pingling cross-section which represents the best exposure of the Luofozhai Group in the Nanxiong Basin and also contains abundant diverse paleontological data. Three formations containing seven members may be distinguished lithologically within the Group: the Shanghu, Nongshan, and Gucheng formations.

Shanghu Formation: This unit is 376.63 m thick, conformably overlies Nanxiong Fm., is dominated by dark purple-red and dark tan silty sandy mudstones interbedded with calcareous silts to fine sandstones, is partially interbedded with sandy conglomerate lenses, and contains abundant calcareous ginger-shaped concretions. The unit is subdivided into three members based upon the quantity of calcareous concretions, grain size, and paleontological data.

The 89.15 thick lower Pingling Mem. is characterized by dark purple-red and dark tan silty mudstone interbedded with a complex of sandstones and three units of calcareous siltstones that are abundant in 1-3 cm diameter calcareous concretions. Principle characters of this member include grain size being relatively coarse, interbedding with calcareous sandstones, and being abundant in ginger-shaped calcareous concretions. It produces fossil vertebrates, gastropods, ostracods, and charophytes.

The middle 124.22 m thick Xiahui Mem. consists of dark purple-red and dark tan silty mudstones interbedded with tan and light gray-green bands or thinly laminated calcareous units. Its base consists of a 1.1 m thick laterally discontinuous calcareous conglomerate that produces fossil vertebrates, gastropods, ostracods, and charophytes. Compared to the underlying Pingling Mem. it is finer grained and contains fewer calcareous concretions.

The 163.26 thick upper Nilongxiang Mem. is more fine grained than its underlying counterpart, consists of dark purple-red silty mudstone partially interbedded with calcareous mudstone, but the top of the section is obscured. It produces ostracods, gastropods and charophytes.

* Yuping Zhang pers. com., Jie Yeh pers. com. to translator.

Nongshan Formation: This 354.89 m thick unit is dominated by tan and dark red argillaceous siltstone interbedded with gray-green marls. In the upper section it is represented by intertonguing differentially thick light tan calcareous siltstones interbedded with either bands or thinly laminated units of sandy conglomerate. Lithologic character readily distinguishes the Zhuguikeng and Datang members.

The 113.10 m thick Zhuguikeng Mem. consists of a tan (near the basal section interbedded with tan-red) silty mudstone interbedded with blue-gray or gray-green marls and partially interbedded with gravelly sandstone lenses. This member produces vertebrates, worm burrows, stromatolitic beds, gastropods, ostracods, charophytes, and plant macro-fossils. This member is characterized by its relatively well developed gray-green marls and being generally relatively fine grained with only a minimum of coarse clastics present.

The 241.79 m thick Datang Mem. is dominated by dark tan silty mudstones interfingering with differentially thick light tan calcareous siltstones and interbedded with blue-gray and gray-green marls, sandy conglomerates, and coarse gravel bearing banded or thinly laminated sandstones. The lower section which bears calcareous concretions produces ostracods, charophytes, gastropods, turtle, crocodile, and mammals. This unit is distinguished from the underlying Zhuguikeng Mem. by being relatively coarse grained, and the presence of well developed calcareous siltstones interbedded with rather numerous sandy conglomerates and gravelly sandstones.

Gucheng Formation: This 410 m thick unit consists of tan-red and gray-black intertonguing mudstones interbedded with silty to fine grained banded or thinly laminated sands. The upper section is predominantly tan silty mudstone with the top unobservable. This formation is recognized with two members.

The lower unit is the 271.59 m thick Maojiwan Mem. consisting of tan-red and gray-black intertonguing mudstones interbedded with banded or thinly laminated calcareous silts to fine sandstones and the top section consisting of calcareous mudstones that produce ostracods and pollen. It is characterized by its relatively fine grained sediments and well developed gray-black and tan-red mudstones.

The upper 139.15 m thick Zhenxianyan Mem. is dominated by dark tan silty mudstones interbedded with gray-yellow and gray-green silty mudstones. It is partially interbedded with tan siltstones. Paleontological data is absent from this unit.

Stratigraphic nomenclature

Luofozhai Group

Zhang and Tong (1963), during their research on fossil mammals, were the first to erect an independent stratigraphic unit set apart from the upper Nanxiong Group, which they established as the Luofozhai Fm., and recognized its age as Paleocene. Subsequently, Zheng et al. (1973) split the Luofozhai Fm. into two members based upon the results of their 1964 expedition to collect fossil mammals. Later Chow et al. (1973, 1977) erected the nomenclature Shanghu Member for the lower member, with its age as Middle Paleocene, and the Nongshan Member for the upper unit, with its age as Late Paleocene. Work conducted in 1973 by Y.S. Tong and his colleagues in the Nanxiong and Chijiang basins resulted in further discoveries of Middle and Late Paleocene mammals. Consequently, Tong et al. (1976) elevated the Shanghu and Nongshan members to formational status and subdivided the Nongshan Fm. into the Datang and Zhuguikeng members in addition to elevating the original Luofozhai Fm. to group status and designating it as representing all the Paleocene sedimentation within the Nanxiong Basin. Guan (1973, 1978) described the Ostracoda in the Nanxiong Basin referring to the Upper and Lower Luofozhai Fm. He and Huang

(1979) believed that since the formational status of the Luofozhai nomenclature had endured such extensive usage, that it was not necessary to elevate it to group status. They also proposed that since there is no type locality of Nongshan north of the village of Luofozhai, Hukou Commune, that the nomenclature Nongshan Fm. should be abandoned and the nomenclature Luofozhai Fm. should only be applied to sediments recognized as the upper member while the lower member be erected as the Shanghu Fm. This text believes that since the 1976 Nongxiang Redbed Field Conference, there has been increasingly wide acceptance of the nomenclature Shanghu Fm. and Nongshan Fm. to represent the Lower to Middle Paleocene and Upper Paleocene respectively in the Nanxiong Basin. Concurrently, the 1:500,000 Hukou topographic quadrangle distinctly designates the geographic feature Nongshan Peak located approximately 250 m directly west of the village of Xincengxia, Luofozhai. Thus in order to maintain consistency in stratigraphic nomenclature, the Nongshan Fm. is retained and the Luofozhai sequence is recognized as group status. This text recognizes the Luofozhai Group *sensu lato* as encompassing the entire set of sediments overlying the Nanxiong Fm. in the Nanxiong Basin. This sequence consists of relatively fine grained sandy mudstones and includes the Shanghu, Nongshan, and Gucheng formations which represent the latest Cretaceous to earliest (?) Eocene. This is basically consistent with the consensus reached at the Nanxiong Redbed Field Conference and is a little broader in scope than the definition of the Group as initially proposed by Tong et al. (1976) as it includes the sediments in the Pingling cross-section they erected as the Danxia Fm. (?).

Shanghu Formation.

In this study, it is noted that the ostracod faunal complex in the lower section of this formation differs from those in the middle and upper sections. The lower section consists of a (?) *Porpocypris* fauna with 10 genera and 19 species, among which are 6 species of *Cypridea*, constituting 25.54% of the complex and two species of (?) *Porpocypris* constituting 16.32% of the complex. This assemblage contains taxa that are frequently documented in, and strictly characteristic to, the Late Cretaceous, including *Porpocypris obiculata*, *P. sphaeroidalis*, *Cypridea xindianensis*, *C. nanxiongensis*, *C. diplonoda*, *C. (P.) subterta*, *C. (P.) gigantea*, *Quadracypris dalangshanensis*, *Parailocypris taizhouensis*, *Cyprois guangzhouensis*, and *Cyclocypris minuta*. However, in the middle and upper members, typical Mesozoic taxa, such as *Cypridea*, *Quadracypris*, *Cristocypridea*, and *Porpocypris*, have become extinct, to be replaced by *Ilyocypris* and *Eucypris*, which represent distinct Cenozoic complexes.

Charophyte assemblages also illustrate this phenomenon with the lower member of the Shanghu Fm. predominantly containing taxa represented by small oogonia such as *Latochara curtula*, *L. guangdongensis*, *Charites guanpingensis*, *Ch. hengjiangensis*, and *Hornichara dalangshanensis*, which are distinctly Cretaceous. In the middle and upper members the taxa are replaced by the prolific, large, and tubercularly ornamented oogonia including *Peckichara*, *Stephanochara*, and *Neochara*. Thus the microfossil evidence indicates the Shanghu Fm. contains the Cretaceous/Tertiary boundary. Moreover, in the Xiyan section 1500 m west of the village of Gaotiancun the Pingling Mem. of the Shanghu Fm. in the Pingling cross-section produces an ornithischian dinosaur mandible. Also, in the Dafeng section approximately 500 m east of the village of Shuinancun, dinosaur eggs were recovered. Both of these occurrences are consistent with the microfossil data and confirm a Cretaceous age for the lowest member.

From a lithostratigraphic perspective, the Shanghu Fm. is predominantly composed of dark purple-red and dark tan silty mudstones, although a detailed examination indicates the three members within it are characteristic, with the lower member interbedded with sandstones and calcareous siltstones that are abundant in calcareous ginger concretions. The middle member is interbedded with calcareous siltstones but calcareous concretions are minimal. The upper member is interbedded with calcareous mudstones and calcareous concretions are even more rare. It is thereby evident that the Shanghu Fm. represents a fining upwards sequence with a diminishing carbonate content. Hence, the lithostratigraphic data also supports the recognition of three

members. In conclusion, this text formally proposes the subdivision of the Shanghu Fm. into three members based upon microfossils, macrofossils, and lithologic character. Nomenclature is derived from the three regional villages of Pingling, Xiahui, and Nilongxiang. The age of the Pingling Mem. is recognized as latest Cretaceous, the Xiahui Mem. as Early Paleocene, and Nilongxiang Mem. as Middle Paleocene. The Shanghu sediments are retained as formational status regardless of the chronologic boundary, because basically all three members are lithologically consistent.

Nongshan Formation.

This text concurs with the diagnosis of Tong et al. (1976) who recognize the formation as representing Late Paleocene deposition within the Nanxiong Basin. The lithologic character and paleontological data in the Zhuguikeng and Datang members are distinct and correlate to the lower and middle members recognized by Zheng and Qiu (1979), the upper Luofozhai Fm. of Guan (1978), and the middle and lower section of the Luofozhai Fm. of He and Huang (1979).

Gucheng Formation.

In the Pingling cross-section there is a set of sediments approximately 410 m thick overlying the Nongshan Fm. that is lithologically distinct and contains taxonomically distinct paleontological data. These sediments are best developed in the vicinity of Gucheng Village, which is regarded as the type locality. The age of the sediments is regarded as Eocene (possibly Early Eocene). The type section of the lower member is at Maojiwan Village where it consists of interfingering tan-red and gray-black mudstones interbedded with silty to fine sandstones. The Upper Zhenxianyan Member consists predominantly of dark tan silty mudstones. This formation is generally equivalent to Unit 3 of the Luofozhai Fm. as recognized by the 706th Geologic Survey, the Danxia Fm. (?) as recognized in the Pingling cross-section of Tong et al. (1976), Unit 5 of the Pingling cross-section of He and Huang (1979), and the Upper Member of the Nongshan Fm. of Zheng and Qiu (1979).

Danxia Group (Formation, Unit)

The geologists Jinglan Feng (Feng Ching-lan) and Huisheng Zhu (Chu Hui-sheng) published upon a 1928 geological and mineralogical reconnaissance in Qujiang, Renhua, Shixing, and Nanxiong counties. In the Nanxiong Basin they subdivided a sequence of the Red Beds into the Danxia Unit (beds) and Nanxiong Unit based upon grain size. The lower section was defined as a set of coarse clastics dominated by conglomerates, related interfingering red sandstones, and interbedded with one foot to several inch thick red shales. The type section of these sediments is at Mt. Danxia in Renhua Co. where the geomorphologically characteristic Danxia Topography is documented.

Guoda Chen (Ch'en Kuo-ta) (1938) conducted a study of the upper Danxia conglomerates, pointing out that Feng and Zhu (1928) recognized the conglomerates as a single unit because the Nanxiong Basin is a northeast trending synclinal basin with the southwest and northeast conglomerates representing opposing wings of the syncline and thereupon being stratigraphically equivalent.

Subsequently Feng (1939) reiterated that the Danxia Unit represented the lower sandy conglomerates in the red lithologic system, and that these beds were deposited as a set of coarse clastics dominated by sandy conglomerates which are quite distinct from the Nanxiong Unit, which is characterized by claystones and fine clastics. Thus, Feng recognized the Nanxiong and Danxia units as distinct lithostratigraphic units and he subsequently concluded that the Nanxiong Basin was in fact not a synclinal basin, but instead was generally represented by a northwest trending monocline. Consequently, the sandy conglomerates in the northwest and southeast were in

superposition and not contemporaneous. From the inception to completion of the basin formation in several of the basin margin regions, deposition was basically represented as coarse clastics, including conglomerates and sandy conglomerates and are particularly well developed in the northeast margin of the basin. Thus based upon lithologic character, these sediments should represent the Danxia Group, and are clearly diachronous, although due to the lack of paleontological data to support this contention, further subdivision was not possible. This interpretation led to the concept of the Danxia Unit (Group, Formation) although its age and stratigraphic relationship to the other stratigraphic units such as the Nanxiong Fm. and Luofozhai Group was nebulous.

The majority of workers recognized the “Danxia Fm.” as a set of Late Cretaceous or Paleocene coarse clastics dominated by brick red and dark red massive conglomerates and sandy conglomerates that unconformably overlies the “Luofozhai Fm.” This text believes that applying this definition is not consistent with field observations made by numerous workers, and that in actuality the description provided by Tong et al., (1976) is more applicable, in which they state that the Nanxiong Basin sandy conglomerates not only appear at the base of the sequence (the basal Nanxiong Fm.) and top of the red units, but can also be interbedded within the red system as units attaining 100 m thick, as represented in the Yangmei region where the sandy conglomerates are documented as a facies change in the purple-red mudstones of the Shanghu Fm. South of the village of Shangluotian, the sandy conglomerates produce dinosaur eggs and should thus be considered the Nanxiong Fm., whereas the sandy conglomerates north of the village produce Paleocene mammals. In the Sanfudi region north of the town of Nanxiong, there are sandy conglomerates that may represent a facies change of the usually purple-red mudstones of the Nongshan Fm. Consequently, the formerly designated Danxia Unit which may have been regarded Late Cretaceous may be Paleocene or even Eocene (?). Or to reiterate, the so-called Danxia Unit is in actuality a misnomer for separate diachronous sandy conglomerates (Tong et al., 1976, p. 20, 22).

The geologic map of the Nanxiong Basin compiled by the 706th Geologic Survey also clearly illustrates that in the northeast margin of the basin there are sandy conglomerates that represent facies changes in the vicinity of the villages of Lantianwan, Miaoqian, Jingkou, Laohuling, and Zhenxianyan, distributed throughout the Nanxiong Fm. and Luofozhai Group (Shanghu, Nongshan, and Gucheng fms.). These beds were traced laterally to confirm this interpretation in 1978.

In conclusion, this text regards the Danxia Unit, which was characterized by its predominance of conglomerates and sandy conglomerates, to be a complex of independent diachronous coarse clastics representing Nanxiong Basin margin sedimentation spanning the Late Cretaceous to Eocene. Its upper and lower boundaries in addition to chronological constraint vary regionally. The Danxia Unit spans the entire geochronology of the basin, the lithological character of the conglomerates is relatively complex, and depositional history relatively long (generally recognized from the early Late Cretaceous to the Eocene), thus formational nomenclature of this unit is hereby abandoned and the sediments are elevated to group status. The Danxia Group facies change relationship with the Nanxiong Fm. and Luofozhai group is illustrated in Figure 2.

Paleontology and Chronology

Shanghu Formation.

Vertebrates: The Bemalambdidae are the representative mammals produced from this formation. Chow et al. (1977) diagnosed its age as Middle Paleocene and Zheng and Qiu (1977) recognized it as Early to Middle Paleocene. To date, however, there are no vertebrates documented from the Shanghu Fm. in the Pingling cross-section.

Paleogene	E ₂	Luofozhai Group	Gucheng Fm.	Zhenxianyan	D a n x i a G r o u p
				Maojiwan	
E ₁ ³	E ₁ ³	Luofozhai Group	Nongshan Fm.	Datang	D a n x i a G r o u p
				Zhuguikeng	
E ₁ ¹⁺²	E ₁ ¹⁺²	Luofozhai Group	Shanghu Fm.	Nilongxiang	D a n x i a G r o u p
				Xiahui	
Cretaceous	K ₂	Nanxiong Fm.	Nanxiong Fm.	Pingling	D a n x i a G r o u p
				Zhenshui Mem.	
				Zhutian Mem.	
				Dafeng Mem.	

Figure 2. Depositional relationship between the Danxia Group and the Luofozhai Group and Nanxiong Fm.

Gastropods: Yu (1977) described two gastropod bearing units in the Shanghu Fm. of the Pingling Cross-section: The middle and lower members produce a fresh-water Prosobranchia complex including *Nystia luminosa*, *Hydrobia datingensis*, *Fluminicola guangdongensis*, *Ammicola datangensis*, and *Grandipatula? deformus*. The upper member contains a terrestrial Pulmonata assemblage with large quantities of *Agallospira multispiralis* and *Zhengjiangospira dignata* in. These assemblages, representing a unique Paleocene complex, differ from the typical Chinese Late Cretaceous faunas in addition to the Eocene faunas.

Charophytes: The expedition conducted by the author of this text recovered abundant charophyte complexes from the Shanghu Fm. The Pingling Mem. produced 9 genera and 16 species including *Nemegtichara prima*, *N. quadrata*, *Hornichara dalangshanensis*, *Obtusochara brevicylindrica*, *O. ovalis*, *O. lanpingensis*, *Charites guanpingensis*, *Ch. hengjiangensis*, *Ch. minutissima*, *Gobichara deserta*, *Rhabdochara cf. buxinensis*, *Rh. jiangduensis*, *Grovesichara changzhouensis*, *G. kiclani*, *Grambastichara ampliiovata*, and *Gyrogonna? qianjiangica*, among which *Charites*, *Hornichara*, *Obtusochara*, *Rhabdochara*, and *Nemegtichara* are the most abundant. Nearly all the species are descendants from predecessors in the Nanxiong Fm. *Charites guanpingensis*, *Ch. hengjiangensis*, and *Hornichara dalangensis* are abundant characteristic species in the Nanxiong Fm. The former has an extensive biogeographic distribution throughout the Late Cretaceous of China including the Paomagang Fm. on the Jiangnan Plane, the Chishan Fm., Jiangsu Province, Daijiaping Fm., Hunan Province, and Sanshui and Dalangshan fms., Guangdong Province. The latter two species are typically represented in the Dalangshan Fm., *Grovesichara changzhouensis* is rare in the Pingling member of the Pingling cross-section, as it is only documented in one hand sample, but with an extremely high count. It is noteworthy that this species appears in the Zhenshui Mem. of the Nanxiong Fm., representing the lowest first occurrence for the species and indicating its genesis to be in the latest Cretaceous and thus it is not characteristic solely to the Early Tertiary.

The Xiahui Mem. of the Shanghu Fm. produces a distinct charophyte complex of 12 genera containing 20 species including *Gobichara lauta*, *Rhabdochara jiangduensis*, *Rh. contracta*, *Grambastichara ampliiovata*, *Grovesichara keilani*, *Stephanochara brevivalis*, *St. huanginensis*, *St. cuneiformis*, *Peckichara zuomaligensis*, *P. subspherica*, *Obtusochara lanpingensis*, *Charites fusca*, *Neochara squalida*, *Gyrogonna huajiazhuangensis*, *G. cataneiformis*, *G. supracompressa*,

Croftiella humilis, *Sinochara guangdongensis*, and *S. caopiensis*. The assemblage is dominated by the large tubercularly ornamented *Gyrogona*, *Stephanochara*, *Peckichara*, *Rhabdochara*, and *Sinochara* which is extremely close to the Zhuguikeng Mem. of the Nongshan Fm. and is extremely distinct from the underlying Pingling complex.

The assemblages documented above illustrate two distinct charophyte complexes in the Shanghu Fm., with that in the Pingling Mem. reflecting a legitimate Late Cretaceous complexion that is intimately related to, and distinctly descended from the taxa in the underlying Nanxiong Fm. The taxa are all Mesozoic forms representing the latest Cretaceous but also document the presence of the prolific Cenozoic species *Rhabdochara changzhouensis*. The Xiahui Mem. reflects a Cenozoic complex completely and is thus regarded as Paleocene. Typical Mesozoic genera such as *Latochara* become extinct. Consequently, from the perspective of successional charophyte stages, the K/T boundary should be represented between the Pingling and Xiahui members, which is consistent with the ostracod faunas.

The Shanghu Fm. ostracods are abundant with the complexes represented in the three members differing as follows. The Pingling Mem. produces 10 genera and 18 species including *Cypridea xindianensis*, *C. nanxiongensis*, *C. elongata*, *C. diplomoda*, *C. (P.) subtera*, *C. (P.) gigantea*, *Quadracypris dalangshanensis*, *Porpocypris orbiculata*, *P. sphaeroidalis*, *Parailocypris taizhouensis*, *Ilyocypris subhuangqiaoensis*, *Cyprois guangzhouensis*, *Cyclocypris minuta*, *Eucypris* cf. *sanshuiensis*, *E. pinglingensis*, *Candona (Candoniella) porrecta*, *C. (C.) postrotunda*, and *Limnocythere nemegtensis*. The Xiahui Mem. produces 5 genera and 5 species including *Eucypris* cf. *sanshuiensis*, *Ilyocypris subhuangqiaoensis*, *Candona (Candoniella) postrotunda*, *Cyprois? guangzhouensis*, and *Limnocythere nemegtensis*. The Nilongxiang member produces 6 genera and six species including *Eucypris shanshuiensis*, *Parailocypris changzhouensis*, *Ilyocypris macilenta*, *Cypris pyriformis*, *Cyprois robusta*, and *Metacypris biformis*.

The Shanghu Fm. contains three distinct ostracod complexes with that in the Pingling Mem. reflecting a distinct Late Cretaceous complexion intimately related to the underlying Nanxiong Fm. and is consistent with the faunas from the Langshan Fm. Sanshui Co., Dongtang Fm. Hengyang Co., Wujia Fm. Hepu Co. in Guangdong, Mengyejing Fm. western Yunnan Province, Taizhou Fm. eastern Jiangsu Province, and the Mingshui Fm. on the Songliao Plane in Northeast China. From the perspective of successional stages, the ostracod assemblage in the Pingling Mem. is intimately related to and descended from the Late Cretaceous, being quite distinct from the Early Tertiary faunas, and consequently is regarded as latest Cretaceous.

The ostracod faunas from the Middle Xiahui Mem. and the Upper Nilongxiang Mem. are intimately related, each containing a *Eucypris-Ilyocypris* fauna, dominated by the species *E. sanshuiensis*. This species is characteristic for the Xin Zhuang Fm. in the Zhu Basin of the Pearl River (Zhujiang) Delta, the Chijiang Fm. of Jiangxi Province, the Shangyang Fm., Hepu Co., Guangxi Province, and frequently occurs in the Zhuguikeng Mem. of the Nongshan Fm. in Nanxiong. *Parailocypris changzhouensis* is frequently documented in the Early Tertiary of South China. *Cyprois robusta*, *Cypris pyriformis*, *Metacypris biformis*, and *Ilyocypris macilenta* are also documented in the Xin Zhuang Fm. of the Pearl River delta. Furthermore, the extinction of typical Late Cretaceous taxa including *Cypridea*, *Cristocypridea*, and *Quadracypris* is characteristic for this period, further reflecting a Cenozoic age for the Middle and Upper members of the Shanghu Fm., or a Paleocene age. The ostracod faunas and stratigraphic position of these members indicate it an appropriate assignment them to the Lower through Middle Paleocene respectively.

In summary, diagnoses based upon the Mammalia and Gastropoda indicate a predominantly Paleocene age for the Shanghu Fm. Charophytes and ostracods indicate the Pingling Mem. is Mesozoic but the Xiahui and Nilongxiang members contain a typical Cenozoic fauna and flora. This is also confirmed by the presence of Late Cretaceous specimens including an

ornithischian dinosaur and dinosaur eggs in Pingling Mem. equivalent sediments at the village of Gaotiancun and south of the town of Nanxiong.* It is thereby concluded that the age of the Shanghu Fm. in the Nanxiong Basin spans the latest Cretaceous to Middle Paleocene, with the Pingling Mem. representing the latest Cretaceous, generally correlated in China to the second member of the Dalangshan Fm, the second member of the Taizhou Fm. and second member of the Mingshui Fm. In North American it is correlated generally to the Lancian Stage and in Europe to the Danian Stage. The Xiaohui and Nilongxiang members are Early to Middle Paleocene respectively and are correlated to the European Montian Stage and the North American Puercan, Dragonian, and Torrejonian stages (Table I).

Nongshan Fm.

Vertebrates: Zheng and Qiu (1979) document the following mammals from the Zhuguikeng Mem. of the Nongshan Fm.: *Pachyaena?* sp., Phenacodontidae, Archaeolambdidae, and cf. Phenacodontidae. The Datang Mem. produces *Lestes datangensis*, *Huaiyangale* sp., Pseudictopidae, Archaeolambdidae, Edentata, Primate, and the crocodile *Planocrania datangensis*. The Zhuguikou Mem. in the Hukou cross-section produces the turtle *Hokouchelys chenshuensis* and the crocodile *Asiatosuchus nanlingensis*. The most notable mammalian faunal character of the Nongshan Fm. is the extinction of the Bemalambdidae, primitive Mesonychidae, and primitive Anagalidae with their replacement by Archaeolambdidae, Phenacodontidae, Arctostylopidae, and derived members of the Anagalidae and Mesonychidae. The arctostylopids most closely compare to *Asiostylops* from the lower Chijiang Fm. of Jiangxi Province and are morphologically more primitive than the North American Early Eocene genera and *Anatolostylops* from the Shisanjianfang Fm. of Xinjiang Autonomous Region. The Pseudictopidae approach those from the Paleocene Taizicun Fm. in Xinjiang while the phenacodontids, arctostylopids, and derived anagalids and mesonychids resemble the taxa principally documented in the Gashato Fm. of Mongolia. Consequently, the basic complex of the Nongshan Fauna can be generally correlated to the Gashato Fm. of Mongolia, the Chijiang Fm. of southern Jiangxi Province, the Doumu Fm. of Anwei Province, the Taizicun Fm. in the lower Shuangtasi Group, Xinjiang, and the Naomugen Fm of Inner Mongolia, all of which represent the Late Paleocene.

Paleobotany: The 706th Geological Survey documented the plant macro-fossils *Palibinia pinnatifida* and *P. korowinii* in the Nongshan Fm. approximately one km northwest of Datang. The former species is also recorded in the Chashan'ao Mem. of the Xialiushi Fm., Hengyang Co., Hunan province and in the Middle Eocene of Zhangyi, Ningxia Autonomous Region. The latter species characteristic for the Xiawanpu Fm. of Hunan, Wulidui Fm. of Henan, the Bailuyuan Fm. of Shaanxi, and the Badkhyz Fm. Turkmenya, Russia. The Russian unit producing the plants is overlain and underlain by facies producing marine bivalves and Foraminifera, the age of which is diagnosed as Middle to early Late Eocene. It is noteworthy that currently in China the genus *Palibinia* is restricted to the Paleocene Xinzhuang to Middle Eocene Baoyue Fm. of the Sanshui and Longgui basins in the Pearl River Delta, with its most frequent occurrence in the Buxin Fm. Recently, this genus has also been documented at the village of Xincun at the eastern margin of the Sanshui Basin from a unit that underlies sediments producing bemalambdid mammals, which are recognized as Paleocene. It is thereby concluded that the genus *Palibinia* has a first occurrence in the Paleocene and becomes more prolific later in the Eocene.

Charophyta: Huang (1979) documented the following 9 genera and 13 species from the Nongxiang Fm. of the Luofozhai and Pingling cross-sections: *Crovesichara changzhouensis*, *Maedleriella nanxiongensis*, *Peckichara longa*, *P. varians*, *Stephanochara brevivalis*, *St. hukouensis*, *Harrisichara poculiformis*, *Rhabdochara changzhouensis*, *Rh. luofuzhaiensis*,

* Subsequent to the completion of this manuscript in November, 1981, further confirmation that the Pingling Member in the Pingling cross-section is Late Cretaceous is supported by the documentation of two dinosaur eggs discovered in March, 1983, by members of the Petroleum Office, Ministry of Geology.

Neochara sinulata, *Sinochara rudongensis*, *S. dongtaiensis*, and *Gobichara deserta*. *Peckichara varians* is characteristic of the Western Europe Sparnacian Stage. *Gobichara deserta* is documented from the “White beds” of Nemegt, Mongolia, which has a faunal complexion that resembles extremely closely the Cuisian Stage in the Paris Basin of France. In China the Nongshan complex resembles those from the first and second members of the Kongdian Fm., Shandong Province, the middle and upper members of the Xingouzui Fm. on the Jiangnan Plane, and the second to the fourth formations of the Funing Group, Jiangsu Province, all of which are recognized as Early Eocene.

Laboratory results from the collections leading to this text produced 17 genera with 51 species of charophytes from the Nongshan Fm.: *Maedlerisphaera minleensis*, *Charites minutissima*, *Ch. fusa*, *Gobichara deserta*, *G. lauta*, *G. granda*, *Rhabdochara jiangduensis*, *Rh. buxinensis*, *Rh. changzhouensis*, *Rh. contracta*, *Rh. luofuzhaiensis*, *Rh. kisgyonensis*, *Grambastichara ampliовata*, *Grovesichara changzhouensis*, *G. kielani*, *G. stepanovi*, *Stephanochara breviovialis*, *St. fortis*, *St. xibucunensis*, *St. huangjinensis*, *St. cuneiformis*, *St. funingensis*, *St. hukouensis*, *St. kiangsuensis*, *St. conspicua*, *Peckichara zhumalingensis*, *P. subspherica*, *P. varians*, *P. minoriquadrata*, *P. coronata*, *P. longa*, *Neochara squalida*, *N. huananensis*, *N. magna*, *N. sinuolata*, *N. xinzhuangensis*, *Gyrongona huajiazhuangensis*, *G. cataneiformis*, *Sinochara guangdongensis*, *S. rudongensis*, *S. dongtaiensis*, *Harrisichara yunlongensis*, *H. poculiformis*, *Turbochara aechma*, *T. specialis*, *Pseudolatochara* sp., *Sphaerochara parvula*, *Raskyaechara shishanensis*, *R. xinghuanensis*, *Croftiella humilis*, *C. steniformis*. These oogonia are dominated by large tubercularly ornamented species. The most diverse genera are *Neochara*, *Peckichara*, *Stephanochara*, *Rhabdocara*, *Sinochara*, *Harrisichara*, *Croftiella*, and *Gobichara*. The most abundant taxa are *Neochara squalida*, *N. huananensis*, *Peckichara subspherica*, *P. longa*, *Croftiella humilis*, *Grovesichara changzhouensis*, *Stephanochara breviovialis*, *Rhabdochara jiangduensis*, *Harrisichara yunlongensis*, and *Gobichara deserta*. This flora is extensively distributed in South China and particularly resembles that in the third member of the Xinzhuang Fm. of the Sanshui Basin. The majority of Chinese charophyte workers currently recognizes this assemblage as Early Eocene. But it is noteworthy that the majority of taxa are newly named in China and as such it is extremely difficult to accurately apply them to international correlation. The first record of *Peckichara coronata* is from the North American Late Paleocene and Early Eocene. The Nongshan complex is basically consistent with those in the middle and upper members of the Shanghu Fm. The species *Grambastichara ampliовata*, *Rhabdochara jiangduensis*, and *Gobichara deserta* are all remnants from the Cretaceous Nanxiong Fm., are also frequently documented in the Late Cretaceous of the Sanshui Basin, and the latter species is common in the White Beds of Mongolia. Although there is some controversy regarding the age of these sediments, the general consensus is Late Paleocene.

Gastropoda: Yu (1977) erected the *Policirsas gracilicostata-Nanxiongospira uniptychia* complex as a mixed assemblage of fresh water prosobranchian and pulmonate forms, recording *Policirsas gracilicostata*, *P. obtusospiralis*, *Renistoma regularium*, *R. anomphalum*, *Cirsomphalus laevigatus*, *Amnicola zhenjiangensis*, *Bithynia* aff. *lordostoma*, *Nanxiongospira uniptychia*, *Opea guangdongensis*, and *Pupoides zhenjiangensis* all of which represent an endemic fauna and creates a difficulty in conducting direct correlations. The genus *Circumphalus* is recorded in the Lower Eocene Sparnacian Stage of Europe, while *Polycircus gracilicostata* approaches *P. varicosa* from the Bortonian Stage of the Paris Basin, France. Several taxa are comparable to those from the second and third formations in the Funing Group of Jiangsu Province, and the Chijiang Fm. of Jiangxi Province, recognized as early Early Eocene.

Conchostraca: At Yingbaoqian, Quanan Commune, the Zhuguikeng Mem. of the Nongshan Fm. produces *Paraleptestheria menloaensis* which is extensively distributed in the Paleogene of China, and is also recorded in the Guolang Fm. of Western Yunnan, the Xinzhuang and Buxin Fm. of the Sanshui Basin, the second and third formations of the Changhe Group in Cixi, Zhejiang Province, the Dainan Fm. in Jiangsu Province, and the Mingshui Fm. (?) in

Taikang Co., Heilongjiang, Manchuria, their ages recognized either simply as Eocene (Chen and Shen, 1979) or Early Eocene, (Chen and Shen, 1980)

Ostracoda: Guan (1978) described four genera and five species of ostracods from the “upper Luofozhai Fm.” (Nongshan Fm.) at Luofozhai and Huanshuitang dominated by the species *Sinocypris excelsa* and *S. funingensis* (= *S. subfuningensis*), recognized as Eocene (Guan, 1978) or Late to Early Eocene (Guan, 1979). He (1979) made a subsequent extremely typical collection from Luofozhai in which he recorded three genera and seven species including *Eucypris hukouensis*, *Sinocypris arca* (= *S. excelsa*), *S. subfuningensis*, and *Parailocypris changzhouensis*, among which *Sinocypris* dominates the assemblage. He recognized the age as Early Eocene and correlated the assemblage to the second formation of the Funing Group in Jiangsu, the basal Xialiushi Fm. in Hunan, and the first and second members* of the Buxin Fm., Guangdong.

The expedition resulting in this text recovered an abundant ostracod assemblage from the Nongshan Fm. in the Pingling cross-section, documenting 10 genera and 14 species including *Sinocypris excelsa*, *S. subfuningensis*, *Eucypris sanshuiensis*, *E. squarrosa*, *E. dongguanensis*, *Ilyocypris macilenta*, *Parailocypris changzhouensis*, *Cypris robusta*, *C. buxinensis*, *Cypris pyriformis*, *Cycloocypris nobilis*, *Candona resupina*, *Metacypris biformis*, and *Limnocythere honggangensis*, dominated by the genera *Sinocypris* and *Eucypris*. This assemblage is taxonomically diverse and fundamentally reflects the entire fauna. There are distinctions between the faunas in the Zhuguikeng Mem. and the Datang Mem. but to date, the latter is still poorly represented, and thus provisionally, the two complexes are regarded as a single fauna, the majority of taxa that is shared with the Xin Zhuang Fm. in the Zhu Basin of the Pearl River Delta. There are individual taxa which allow further correlation: *Sinocypris excelsa* is recorded from the second member of the Chijiang Fm., Jiangxi; the Chashanao Mem. of the Xiliushi Fm., Hengyang Co. and the Yuanjiang Fm. at Dongtinghu, Hunan; the Xingouzui Fm. to the northeast on the Jiangnan Plane. *Eucypris sanshuiensis* is characteristic to the Xin Zhuang Fm in the Zhu Basin of the Pearl River Delta. It also occurs abundantly and in a relatively consistent stratigraphic position in the Shangyang Fm. of Hepu Co., Guangxi, and the second member of the Chijiang Fm., Jiangxi. *Parailocypris changzhouensis* is not an abundant species such as *Sinocypris* or *Eucypris*, however it is rather characteristic, with an extensive biogeographic range spanning, the second formation in the Funing Group, the Shuangtasi Group, Changhe Group, Xialiushi Group, Fangjiahe Fm., Shangyang Fm., Xin Zhuang Fm., the Leizhou Peninsula, Guangdong, and the Paleogene of Yuanlong, Yunnan. Furthermore, it frequently occurs concentrated in relatively lower or older sediments. *Metacypris biformis* occurs abundantly in the Xin Zhuang Fm., Dongyuan Basin, and resembles closely *Timiriasevia naranbulakensis* and *T. ulanbulakensis* from the White Beds of the Mongolian Nemegt Basin.

In conclusion, there are two lines of evidence regarding the age of the Nongshan Fm. Vertebrate workers regard it as Late Paleocene but workers on ostracods, conostrachans, gastropods, charophytes and plant macro-fossils regard it as Early Eocene. Opinions of other stratigraphers are also basically consistent, as the vertebrates, ostracods, and charophytes all correlate to the Late Paleocene White Beds of Mongolia. Within recent years bimalambdid mammals (as diagnosed by Yuping Zhang and Banyue Wang) have been recovered from the vicinity of Guanyaoxincun Village at the northeast margin of the Sanshui Basin which may assist in the final resolution of the age of the Nongshan Fm. Constraining the bimalambdid producing sediments are units bearing the macro-plant *Palibinia* associated with charophytes, gastropods, and a large quantity of ostracods (dominated by *Sinocypris*). The stratigraphic position is regarded as being undoubtedly Paleogene. Preliminary research conducted in this text recognizes the sediments possibly as the lower Baoyue Fm. or the upper Buxin Fm. sensu stricto, the ages of which are recognized as Early to Middle Eocene, which contradicts the mammalian data.

* This is equivalent to the Xin Zhuang Fm. and Member I of the Buxin Fm. sensu stricto.

However, the underlying Xinzhuang Fm. is undoubtedly Paleocene, and as described above, the Nongshan Fm. ostracod and charophyte complexes are completely consistent with the Xinzhuang Fm. and extremely similar to the middle and upper sections of the Shanghu Fm. Consequently the age of the Nongshan Fm. should be assigned Late Paleocene.

Gucheng Formation.

The Gucheng Fm. constitutes newly erected stratigraphic nomenclature. Currently, only the lower Maojiwan Mem. produces paleontological data consisting of pollen and ostracods. Wu and Yu (1981)* documented angiosperms as constituting 50.4-80% with an average of 65.5%. There were frequent occurrences of Ulmaceae at 4.2-8.3%, *Rhoipites* at 2.5-6.2%, *Tutaceopollis* at 1.3-3.7%, *Subtriporopollenites* at 1.2-6.3%, *Quercoidites* at 3.0-3.3%, *Centrolepidacidites* at .36-2.6%, *Boehlansipollis* at .5-1.4%, and *Lonicerapollis* at 0.9-3.6%. Gymnosperms constituted 8.6-10.4% with an average of 9.5%, dominated by *Ephedripites* at 1.8-6.5% and a distinct amount of relatively archaic taxa such as *Parcisorites*. Ferns constitute 9.6-41.8% with an average value of 25.2%, dominated by *Pterisisporites* at 7.5-19% with an average value of 12%, and secondarily with *Lygodiumsporites* at 1.8-5.7%. Additional nonarbooreal pollen consist of Chenopodiaceae, *Corsinipollennites*, Centrolepidaceae, and Restionaceae. This complex resembles the latest or Late Paleocene *Pterisisporites*-Ulmaceae or *Ephedripites* dominated complex in the Chijiang Fm. of the Chijiang Basin, Jiangxi. The expeditions by the author of this text also recovered pollen from the Maojiwan Mem. which basically reaffirms the work of Wu and Yu (1981) with a complex dominated by tricolate and tricolporate angiosperms and associated with a distinct amount of perforate forms, *Pterisisporites*, and *Ephedripites*, reflecting an Early Tertiary complexion but also retaining the Mesozoic species *Classopollis annulatus* with a count of 2.3%. The assemblage is concluded to be Early Eocene.

The ostracod fauna is extremely monotonous and poorly sampled as currently there are only two genera and two species represented by *Cyprois buxinensis* and *Candona* sp., with the former dominating the assemblage and also occurring abundantly in the Early Eocene Buxin Fm. of the Sanshui and Longgui basins which is one of the typical units. The ostracod fauna from the Buxin Fm. in the Longgui Basin is also monotonous to the extreme, with well core data documenting the predominance of *Cyprois buxinensis* and associated with minor counts of other taxa. This differs from the Gucheng Fm. although they are currently recognized as being basically correlative, and due to its superposition with the Nongshan Fm. is recognized as Early Eocene.

Finally, it is noteworthy that the fauna from the Gucheng Fm. is not distinct and the upper Zhenxian Mem. is unfossiliferous. Thus, the final assessment of its age must await further study. It is provisionally regarded Early (?) Eocene.

Acknowledgements

Assistance in the field measuring sections and collecting hand samples was provided by Youlang Luo, Jiefang Zhang, Wancai Yuan, Yingqing Peng, Borong Zhum Guorong Qin, and Yingping Liu. Analytical assistance in the laboratory was provided by Yishan Wang and Qinglian Zeng. Charophyte diagnosis was provided by Jiefang Zhang.

* Wu and Yu (1981) regarded these sediments as the upper member of the Nongshan Fm.

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