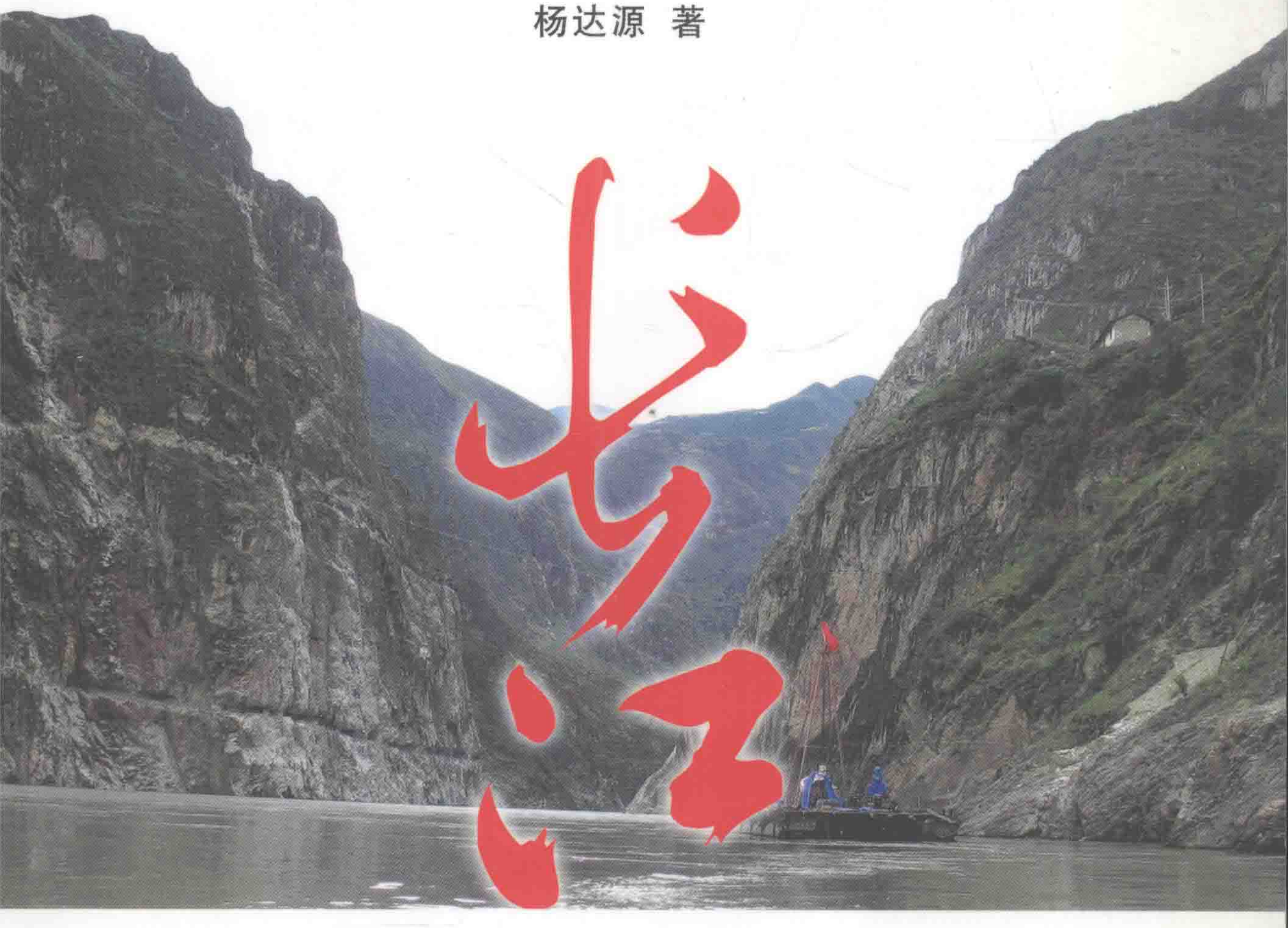
STUDY ON THE CHANGJIANG RIVER

杨达源 著



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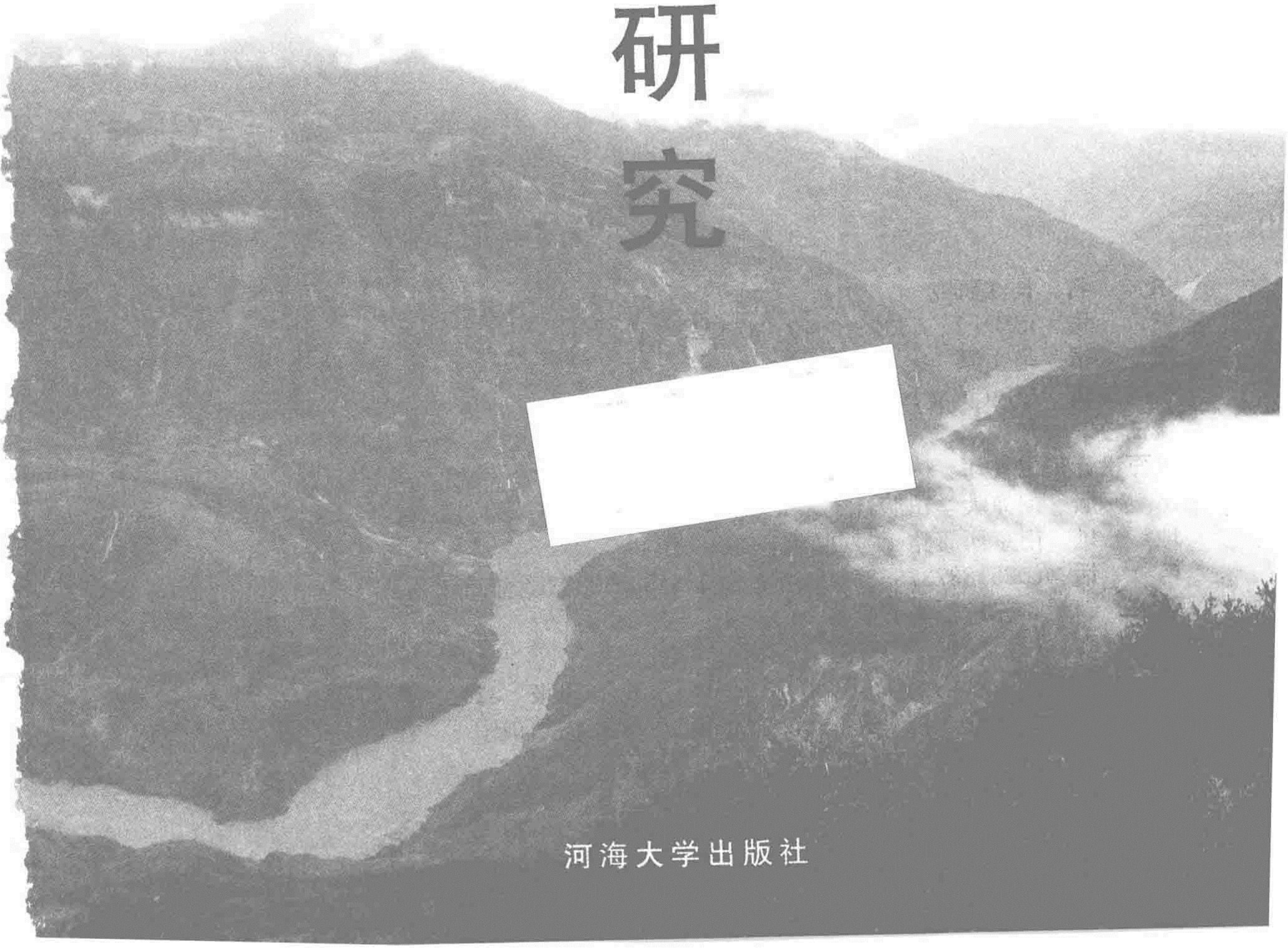

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前　言

长江系世界长河，源于世界屋脊，汇流世界最深大洋，哺育中华文明。因此，研究长江系炎黄子孙祖祖辈辈的心愿和向往。

我的导师杨怀仁教授，曾荡着小木船，经历荆江汹涌洪峰。学生随之，先后25年，自长江口河段逆流而上，直达金沙江上段，汇集点点滴滴心血。铸今日之小集《长江研究》。

400年前的徐霞客，历尽艰难险阻，一步步求证长江之源，精心描绘所见所闻集成游记，今天谓之"奇书"。

我们逆江考察，骄阳下纵观"气、水、生、土、地"，风雨中探索古往今来，吸纳《山海经》以来长江调查研究历史长河思想宝库的精髓，滋润新学术思想萌芽。

巍巍青藏高原及随之发生的川西高原、云贵高原的相继隆升，迫使金沙江东流；奔腾急流日夜深切，造就了多处深及海平面高度以下的深潭深槽；继之将泥沙分送长江中下游两岸洼地，营造一片片泛滥平原，又汇聚长江口，构建了长江三角洲。大江东去，可是世界海平面上升的影响曾向西推进，然而恰恰是刚柔相济，育成长江中下游古往的三大泽——震泽、彭蠡泽和云梦泽，今来的三大湖——太湖、鄱阳湖和洞庭湖……历百万年之久，长江的功能在变化；千年以来，长江研究的学问在深化。最近，我们研究发现，人类大规模修筑江堤曾将河口广陵潮逼进了钱塘湾。为此，我们还期望借助全流域的雨水调度工程，消弱盛夏洪峰，补充隆冬枯流，创造长江流域的最佳人居环境。

曾有专家十分珍惜地告诉作者，每篇论文揭示一两个问题，也许不算什么，如果将其串联起来，就可组构成长约6300 km的珍珠长链，形成贯穿长江全过程的新的学术思想。现在这样做了，还要真诚感谢河海大学出版社对出版本书的大力支持和帮助。

作者仍然还要借此机会，真诚感谢导师杨怀仁教授、20世纪50～60年代曾徒步考察长江三峡的王富葆教授、长江水利委员会勘察局陈德基高级工程师，是他们给了我"他山之石"及种种机会，真诚感谢所在校系的老师和同事，还要感谢北京、上海、广州、成都、杭州和兰州等全国各地的常有来往的校友和同学，是他们给了我指导、支持和帮助。

诚望各位专家学者对书中不足之处，多加指教。

杨达源

2004年10日

目　录

全新世海面变化对长江下游近河口段沉积作用的影响①

海平面是河流地貌发育的基准面，长江中下游的地貌发育与海平面有密切关系，海平面的升降会影响河流的蚀积作用。

长江下游近河口段，是指江西省湖口以下到江苏省镇江附近的长江河段。本河段全长约 540 km，镇江以下到长江口的距离约 282 km。

目前，长江下游河口段的潮流界在镇江以下的江阴附近，距今河口约 196 km，潮区界则在安徽省大通附近，距今河口约 616 km。但在中全新世时期，古长江河口位在今镇江—仪征附近。历史时期，在汉代曾以去扬州观“广陵潮”、去镇江北固山“望海”为饱览壮景之举。古时还有在湖口以下约 31 km 的小孤山观“潮涨潮落”的诗文。由此可见，长江下游近河口段的演变，特别是河漫滩平原的发育，当与海面变化及潮流作用等有十分密切的关系。

一、长江下游近河口段的全新世沉积

长江下游近河口段两侧的漫滩平原都是由松软的全新世沉积所组成。本河段全新世沉积的显著特点之一是厚度大，远远超过河流河漫滩相沉积的正常厚度。

1. 湖口附近

根据江西省水文队的钻探资料，江西湖口梅家洲的全新世沉积厚度达 44.5 m 左右，而且是近 3 800 多年以来形成的。① 标高 17.48 m～0.96 m，浅灰黄亚砂土薄粉砂层。② 标高 0.96 m～－8.59 m，浅灰中细砂层。③ 标高－8.59 m～－10.04 m，浅灰亚砂土层富含有机质，底部样品^{14}C年代为距今约 2 500 a 左右。④ 标高－10.04 m～－18.13 m，浅灰粉砂与砂质。粘土互层，含螺壳。⑤ 标高－18.13 m～－19.73 m，浅灰亚粘土层含有机质，底部样品^{14}C年代为距今 3 205 a 左右。⑥ 标高－19.73 m～－24.22 m，砂砾层。⑦ 标高－24.22 m～－26.96 m，浅黄粉砂含有机质，上部样品^{14}C年代为距今 3 680 a 左右，下部样品为距今 3 830±150 a。（以下为晚更新世早期的沉积）

2. 安庆附近

1972 年，在安庆官洲的东南侧于比今一般洪水位低约 20 m 深处的沉积层中，发现了 300 余株被埋藏的古树，树干长几米到 20 m 不等，主根较粗短，长不过 0.5 m～1 m，但盘根很发达，说明这些古树本是生长在古洲滩上被就地埋藏的古树林，包裹古树的沉积为灰黑色或黑色富有机质的粉砂质粘土，较坚实，多黑斑和黄斑。据北京地理所取古树作^{14}C测年为距今 4 875±100 a。又据丁怀元同志在安庆官洲江底标高－19.6 m 处采灰黑粘土样作^{14}C测年，为距今 4 450±100 a。

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① 国家自然科学基金 9488007 号和中国科学院 87－45－03 号项目联合资助课题研究内容之一。

3. 铜陵附近

安徽铜陵附近长江高漫滩顶面标高 10 m～8.5 m 左右，低河漫滩顶面标高 8 m～6 m 左右。于汤沟 SZK29 号钻孔中，自上而下为：① 标高 9 m～6.12 m，灰黄亚粘土层；② 标高 6.12 m～－30.44 m，青灰粉细砂层；③ 标高－30.44 m～－38.28 m，砂砾层。在其附近的 SZK30 号钻孔中，自上而下为：① 标高 10 m～4.10 m，灰黄亚粘土层；② 标高 4.10 m～－30.87 m，青灰色细粉砂层；③ 标高－30.87 m～－35.97 m，青灰砂砾层。即铜陵附近全新世河漫滩相沉积厚达 40.87 m 左右。

表 1 长江下游近河口段全新世漫滩沉积平均沉积速率的比较

Tab. 1 Mean rate of the flood land deposits in the lower reach of Changjiang River in Holocene

沉积速率 (m/1 000a) \ 地点；时代 (距今1 000a)	湖口 梅家洲	安庆 官洲	芜湖 QK15孔	南京 714厂	镇江 农机学院 南坳谷
1	10.5				
2	2 500±	4.1	5	1.93	
3	13.0				
	3 830±				1.27
4		4 870±			
5			5 300±		
6				6 200±	
7				5	7 620±
8				8 800±	2.62
9					9 730±
10					13

4. 芜湖附近

芜湖附近长江北岸的河漫滩面宽达 4 km 左右。据雍家镇 QK28 号孔及 ZK1391 孔等综合来看，① 标高 7.5 m～－7 m 左右为粉砂粘土夹薄粉砂层；② 标高－7 m～－20 m 左右为粘土层或粉砂层。与 ZK1391 号孔近邻的 QK15 号孔中，上部 8 m 左右为粘土层，以下为粉砂粘土层和粉砂层，到标高－38 m 左右为厚 2 m 左右的砂砾层，其中标高－26 m 左右粉砂层中有机质样的^{14}C 年代为距今 5 300±150 a。

5. 南京附近

蒋斯善等[1]曾对南京市区的秦淮河古道作过详细的调查研究。在南京化工学院附近，表部有 3 m～5 m 厚的人工填土，以下为 20 m～30 m 厚的亚粘土或淤泥质粘土，以及 20 m～25 m 厚的亚砂土或粉细砂层，再往下则为砂砾层。714 厂附近埋深 20 m 左右沉积层中的木炭样品的^{14}C 年代为距今 8 800±300 a，埋深 12 m 的泥炭样的^{14}C 年代为距今 6 190±260 a。

6. 镇江附近

南京大学大地海洋科学系的几位老师曾在镇江农机学院南侧江滨坳谷中安排了钻探取样，得知埋深 32 m 的淤泥样^{14}C 年代为距今 10 850±200 a，埋深 17 m 处含植物残体的亚粘土样为距今 9 730±200 a，埋深 9.5 m 的含植物残体的亚粘土样为距今 7 620±150 a。

根据已有资料，长江下游近河口段中全新世以来的沉积作用比较强盛，沉积速率比较快。湖口附近近 3 800 a 以来的平均沉积速率达 11.7 m/1 000 a(^{14}C)，近 2 500 a 来的平均沉积速率为 10.5 m/1 000 a(^{14}C)左右。芜湖附近近 5 300 a 来的平均沉积速率为 5 m/1 000 a(^{14}C)，南京附近近 8 800 a 以来的平均沉积速率达 2.3 m/1 000 a(^{14}C)左右，镇江附近沿江洼地近 9 700 a 以来的平均沉积速率为 1.8 m/1 000 a(^{14}C)。

更为突出的是，全新世以来不同地点、不同时段的平均沉积速率有比较大的差别，尤其是近河口段的南京和镇江，早全新世以来平均沉积速率有明显递减的趋势，而且递减率有时间差异，镇江在距今 9 700 a 前后就出现平均沉积速率的迅速递减，由 13 m/1 000 a(^{14}C)减为只有 2.62 m/1 000 a(^{14}C)，然后又在距今 7 600 a 前后减为 1.27 m/1 000 a(^{14}C)；南京附近则在距今 6 200 a 前后平均沉积速率由 5 m/1 000 a(^{14}C)减为 1.93 m/1 000 a(^{14}C)。本河段的中段，中晚全新世的平均沉积速率相当于南京附近距今 6 200 a 以前的平均沉积速率。本河段的上段湖口附近，没有距今 3 800 a 多年前的全新世沉积，而距今约 3 800 以来的平均沉积速率又与镇江附近距今 9 700 a 左右以前的沉积速率较相近(表 1)。

二、全新世海面变化及其对长江下游近河口段沉积的影响

早全新世早中期，世界海面曾以较快的速度上升，海水从大河河口溯源向上漫进。根据镇江丹徒镇南约 2 km 江滨洼地中的钻探资料，在标高－4.5 m～4.0 m 段的沉积含有多种海相海陆过渡相微体生物化石，如有孔虫毕克卷转虫变种(*Ammonia becoarii var.*)，透明筛九字虫(*Cribrononion visreum*)，缝裂希望虫(*Elphidium magellanicum*)等，此外还有圆盘形硅藻，盾形化石及轮藻(受精卵膜)等。另外，本岩芯段内还夹有不含海相微体生物化石的薄层泥炭，全段岩芯中还普遍含有较多的植物残体，故确定本岩芯段属滨海河口沉积。它的沉积时代为距今 8 900 a 左右到距今 6 300 a 左右。李从先[2]等考虑潮差的影响后推断距今 8 900 a 左右长江口的水面位置约为－10 m～－12 m，距今 6 300 a 前后镇江附近江水位在－2 m～－3 m左右。

另外，江苏北部沿海和苏南平原沿海地带的调查资料表明，距今 5 000 a 左右曾发生过一次明显的海退，有一薄层陆相沉积夹于上下海浸沉积层之间，陆相沉积中还分布有古文化遗迹。笔者推断，在距今 5 000 a 前后曾发生过一次海面的下降，然后在距今 4 500 a 左右海面又回复到高海面位置，且自那以来的海面变化基本上保持在高海面位置作上下波动[3]。

如果以晚更新世晚期冰期鼎盛时期(距今 18 000 a 前后)世界海面比今低 130 m 左右来计算，那么古长江口的海面变化，从距今 18 000a 左右到距今约 9 000 a，海面的平均上升速率为 13.3 m/1 000 a(^{14}C)左右；从距今 9 000 a 到距今 6 000 a 左右海面的平均上升速率为 2.67 m/1 000 a(^{14}C)，近 6 000 a 来海面的平均上升速率只有约 0.33 m/1 000 a(^{14}C)。亦即全新世以来海面的平均上升速率的放慢趋势也是十分明显的。

把海面的平均上升速率和上述的镇江附近全新世沉积的平均沉积速率的变化相比较，可以发现二者之间具有明显的对应性和同步性。中全新世以来，海面的上升速率比较缓慢，但是由于长江三角洲的发育，长江河口位置的不断向海延伸，镇江附近的长江水位实质上已由－2 m～－3 m 左右上升到目前的多年平均水位 4.57 m 了，即近 6 000 a 以来镇江附近长

江水位的平均上升速率已不是0.33 m/1 000 a(^{14}C),而是1.1 m/1 000 a(^{14}C),它与镇江附近近7 600 a以来的平均沉积速率1.27 m/1 000 a(^{14}C)也是十分相近的。

早全新世早中期海面的迅速上升,长江河口位置则急速后退,到距今6 000 a以来海面上升速率相当缓慢,在这种情况下,长江河口发育了越来越宽阔的三角洲。这一过程反映了海面上升速率变化与河口沉积作用转化的关系。

早全新世海面的迅速上升,长江下游近河口段的最初反映当是水面坡度的迅速变小,涨潮流及其顶托作用影响范围步步向上游推进,随之在长江下游近河口段发生大量的泥砂沉积。泥砂沉积首先充填冰期低海面时期发育的古深槽,然后构筑大量的洲滩。河道中洲滩的发育,伴随着江面的束窄和洪水位的不断上升,把部分泥砂又带到河口近海构筑三角洲。

关于长江下游近河口段近几千年来的水位上升,可以从河漫滩相沉积厚度远远超过河漫滩相沉积正常厚度方面得到证实。河流的河漫滩相沉积的顶面高度比较接近该地河流的洪水位,河流的河漫滩相沉积的"正常厚度"大致相近于该地河流水位的年变幅。从表2中可以看到,长江下游近河口段各地全新世河漫滩相沉积的厚度远远超过近代该地长江水位的最大变幅,也即远远超过河漫滩相沉积的正常厚度。可以认为,全新世河漫滩相沉积厚度减去近代江水位最大变幅的差值,即大体上代表了河漫滩相沉积形成期间附近江水位的上升幅度。在这里还应该说明,所说的江水位上升与河漫滩相沉积增厚,两者是相辅相成亦步亦趋的,并非一方单纯地作为原因另一方作为后果而出现的。

表2 长江下游近河口段河漫滩相沉积厚度与近代江水位最大变幅的比较

Tab. 2 Comparison between thickness of the flood land deposits in the lower reach of Changjiang River with River-Lever

地　点	湖口	安庆	铜陵	芜湖	南京	镇江
近代江水位最大变幅/m*	(九江13.61)	12.96	(大通11.94)	9.51	7.70	6.25
全新世河漫滩相沉积厚度/m	36.05	>30	≈40	44	20～30	≈32

* 是指本世纪以来的最高水位与最低水位的差值,已大于正常水位的年变幅

总之,海面变化对入海河流下游河口段的水位变化以及侵蚀与沉积作用的变化有着深刻的影响,而且这种影响是自下向上逐步发展的。深入研究这个问题,对科学预测未来海面变化的影响具有重要的意义。

注 原文:杨达源,严庠生. 全新世海面变化与长江下游近河口段的沉积作用. 海洋科学,1990(1):9～13

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SEA-LEVEL CHANGE AND DEPOSITS IN THE LOWER REACH(FROM HUKOU TO ZHENJIANG) OF CHANGJIANG RIVER IN HOLOCENE

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Abstract

The flood land deposits formed in Holocene was around 30～40 m in thickness in the lower reach (from Hukou to Zhenjiang) of Changjiang valley, exceeding enormously "the normal thickness" of the flood land deposits formed generally in other valleys, which was related to the constant rise of the flood stage in that period. The latter was resulted directly of indirectly from sea level rise in Holocene.

INFLUENCE OF CLIMATIC AND SEA-LEVEL CHANGES ON THE ALLUVIAL PROCESSES OF THE MID-LOWER REACHES OF THE YANGTZE RIVER IN THE LAST 10 000 YEARS[①]

The fluvial processes, depositional or erosional, are very sensitive to the changes in environment, including changes of the geological structure, tectonics, geomorphic development, vegetation, and especially the climate and sea-level. The alluvial processes varies greatly along the Yangtze river along its whole domain, strong or alternating with weak, and from the Three Gorges segment of the upper reaches downflow-wards the process has been deeply influenced by the glacial-interglacial climate cycles and corresponding sea level changes.

Ⅰ. BASIC CHARACTERS OF THE PROFILE STRUCTURES OF THE LOWLY-LYING TERRACES AND FLOOD PLAINS IN DIFFERENT RIVER SEGMENTS

Fig. 1 outlines the profile structures in different locations, which are: Ⅰ. Nantong for the mouth segment, 194 km from river mouth; Ⅱ. Wuhu(572 km); Ⅲ. Jiujiang (920 km)for the lower reaches; Ⅳ. Huangshi(1 012 km); Ⅴ. Shashi (1 650 km); Ⅵ. Yichang (1 808 km) for the middle reaches and finally; Ⅶ. Wushan (1 966 km) in the Three Gorges segment.

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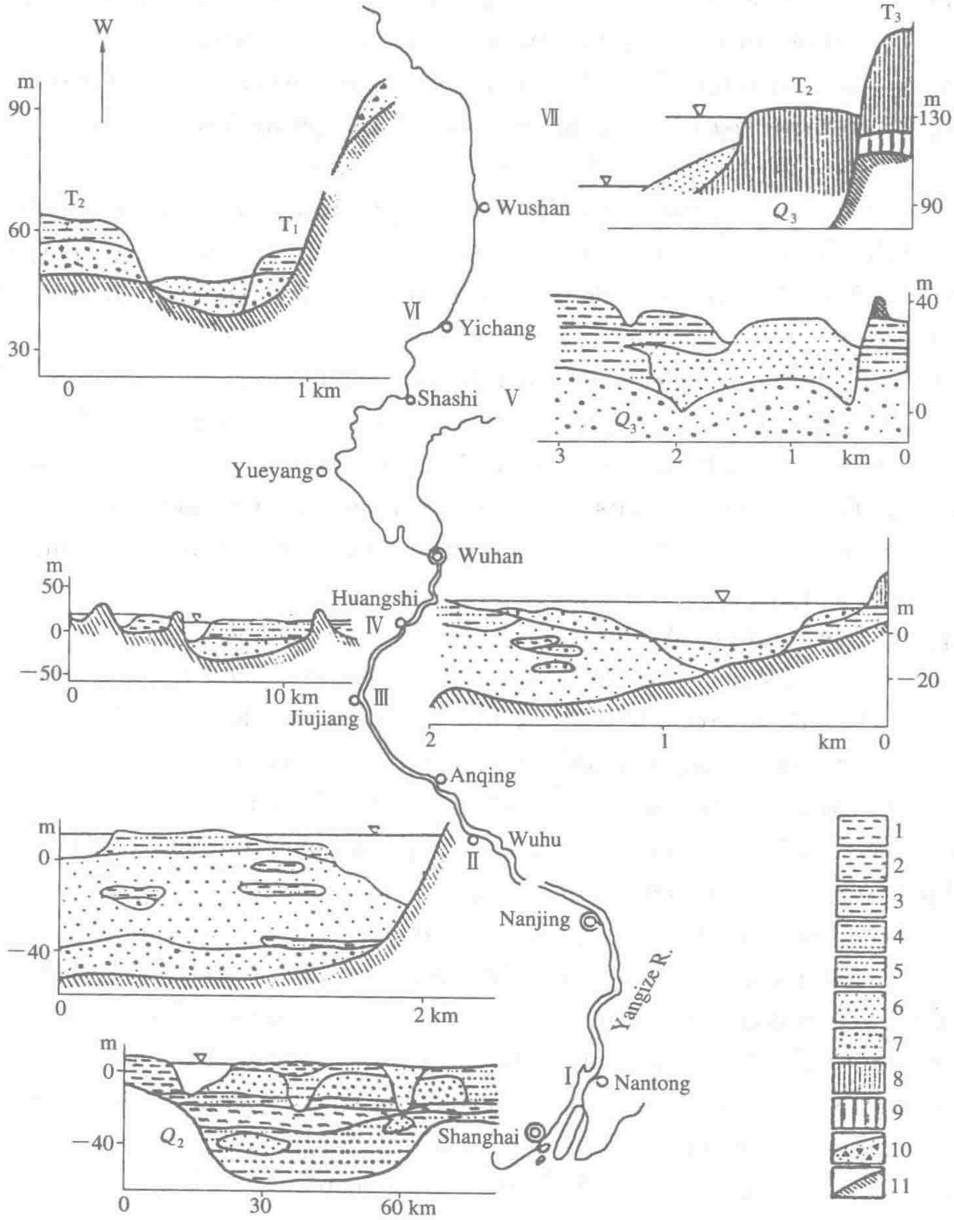

Fig. 1 Profile structures of the lowly-lying(altitude) terraces plus flood plains along the Yangtze River

Ⅰ. Nantong; Ⅱ. Wuhu; Ⅲ. Jiujiang; Ⅳ. Huangshi; Ⅴ. Shashi; Ⅵ. Yichang; Ⅶ. Wushan
1. Silty mud(lacustrine); 2. Clay(flood plain); 3. Sandy clay; 4. Silt or sandy clay (flood plain); 5. Clayey sand (flood plain); 6. Sandy layer (channel facies); 7. Sandy gravel or gravellayer (channel facies); 8. Loess or loessial accumulation (Late Pleistocene); 9. Red clay or paleosol(mid-Pleistocene); 10. Alluvial or slope material; 11. Basement

1. River Mouth Segment

The river mouth segment of the Yangtze River is located in a neotectonic tilting depression area, with Quaternary sediments as thick as 150～300 meters. Since the late Pleistocene, the sediments sequence contains three marines, to marine-continental transitional deposits which constitute 77% of the sequence. The paleo-channel during the glacial incised deeply into these marine, and marine-continental deposits formed during interglacial. The altitudes of the bottoms of the transgression sediments (Q_3 and Q_4) filled in the channel are compared with those mantled on the adjacent bank of the same age. The relative depths of the channel thus obtained are 55 m for early Wrm glacial's and 35 m for late Wrm. The late-Wrm-channel's altitude is 60 m below sea level, i. e. 40 m lower than the modern river channel.

The channel fillings since pleniglacial and the overlapping overbank sediments of Holocene can be divided into two suits of delta sequence from the bottom set to the top set. The lower one started from 12 000 a BP and ended at 6 000 a BP, its burial depths being 50～54 meters. The upper one has its foreset inserted into the lower one as deep as about 22 m. Its topset was formed 2 000 a BP and overlapped universally the lower suit with a thickness of only 4 m[2].

2. Segment Downwards of Wuhan

The segment from Wuhan down to Nanjing is incising into a fault-fracture zoneperipheral to the Dabei mountain region, crossing over several Late Mesozoic inland basins of tectonic depression. The neotectonic differential vertical movement on both sides of the fault zone is still going on presently, the uplift of south side being contrast to the downward of north one, and this determines the general geomorphic contrast between terraces plus flood plains on the north and cliff plus crags on the south.

In the river channel near Wuhu, Jiujiang, and Huangshi, Jocally there are alluvial sand and gravel beds buried and some discontinuous interbands already cemented by calcareous material. The Holocene sediments on both sides of the channel near Wuhu and Jiujiang are as thick as 35～44 m(Fig. 1 - Ⅱ, Ⅲ). The boring cores of QK 15 hole to the north of Wuhu is composed of upper 8 m clay layers and then silt-clay and silt layers, and from 45 m depth down sandy gravel layers. The organic material contained in silt layer at 33 m ± depth is ^{14}C dated at 5 300±150 a BP[3]; the organic material sample from a silt layer at 44 m depth of a core in the outlet of Poyang lake near Jiujiang ^{14}C dated at 3 830±150 a BP[4].

3. Jingjiang Segment

This segment is located in the western Jianghan plain. A remarkable eastward tilting happened in Quaternary here. On the north side of the downcurrent end of the segment, the Quaternary deposits reached more than 150 m thick whereas along the uppercurrent part of the segment, and the river deeply cut down in-between the hills and mounts of basement rock with mid-late Pleistocene unpaired terraces occurring on both banks.

During the last pleniglaciah the Jingjiang river channel cut through the planarly distributed silty clay layers of late Pleistocene, and into the fan-shaped sandy gravels accumulation of mid-Pleistocene. The channel bottom is about 0 m a. s. l. near Shashi(Fig. 1-Ⅴ), where the terrace surface along the segment are about 25～35 m above the channel bottom. In the upper part of the deposits on the terraces, there were developed calcareous concretions simultaneous with the channel down cutting which is roughly dated at 12 900±500 a BP.

During the early Holocene, the Jingjiang river flow east-southeast-ward across the Jianghan plain from Shashi as revealed by the drilling. Channel sand bands are found buried under the plain which witnesses the flow paths. One branch started from Shashi, via Zishi, Qingshi, Beimiao, and Mianyang, then jointed with the Hangshui river. Another branched from Qingshi, via Hongcheng then joined with the outlet flow of the Dongting Basin, and ran towards Wuhan. Later on, owing to the development of the fan-shaped accumulation pivoted at Shashi, many branches occurred downcurrent of Shashi in this segment (Yang, Xia, Yong etc. streams). Lastly, all the flows entered the present channel which is composed of the Jingjiang channel, slightly winding southwards downcurrent of Shashi, and the Xiajingjiang meander. The deposition during Holocene filled all the deep paleochannels, and then formed the flood plain from planar mantling, which buried many ancient culture remains of neolithic age and some paleo-trees. In a core near Lusun lake on western side of Jingjiang right to the south of Shashi, a mud sample was cut at burial depth of 6.9～7.1 m and ^{14}C dated at 3 950±120 a BP. In a core near Babao of Jiangling, a mud sample from depth of 9.8 to 10.0 m has been ^{14}C dated at 5 240±125 a BP. Presently, the flood level in the channel between the dams are 10 meters or more higher than the low-lying plains on both sides.

4. Near Nichang

Nichang is located at the outlet of the Three Gorges. The segment downcurrent from Nichang runs perpendicular to the tilting axis. There are six levels of unpaired terraces along the river which are 120, 102, 75～70, 40～30, 25, and 7～10 m above the general flood-level. The terraces were formed since the mid-Pleistocene[5].

Fig. 1-Ⅳ shows the structure of the channel and branch channel deposits. The middle part of the first level terrace is alluvial gravel beds with surface layer of 2 m thick being calcareously cemented and lithified. The cement is ^{14}C dated at 13 400 ±400 a BP. The upper part is composed of clayey silt layers. The paleo-wood samples from the bottom of this part are ^{14}C dated at 5 340±315 and 5 500±4 230 a BP; and the burned wood(coke) and potter fragments from the silt layers are ^{14}C dated at 5 340±315～4 230±115 a BP. At present, occasionally the flood can cover part of the terrace surface.

The deposits in channel is composed of a lower part of typical alluvial gravel layers and an upper part of 5 m pebbly sand layers. The carbonized wood samples from the bottom and top of lower part are ^{14}C dated at 37 700±1 780 and 13 100±105 a BP.

5. Wushan

Wushan is located at the uppercurrent inlet of the Wuxia gorge where a branch named Daninghe river joins in. There are multi-levels of terraces around Wushan. The lowest one is about 130 m a. s. l. , and the upper part is composed of thick loess with median diameter 5. 0 and sorting coefficient 0. 95. The large, soft, and irregular calcareous concretion contained is ^{14}C dated at 12 200±145 a BP. At present, exceptionally large flood can inundate the marginal part of the terrace and the flood deposits have already mantled the middle and lower parts of its frontal slope and locally cemented by calcareous material, which is ^{14}C dated at 4 240±140 a BP (Fig. 1-Ⅶ).

Ⅱ. THE INFLUENCE OF THE GLACIAL-INTERGLACIAL CYCLES AND SEA-LEVEL CHANGES ON THE ALLUVIAL PROCESS OF THE MID-LOWER REACHES OF THE YANGTZE RIVER

From the above-mentioned data, one can see the obvious influences of the Quaternary glacial-interglacial cycles and sea-level changes on the alluvial process along the mid-lower reaches of the Yangtze River. The climate changes altered greatly the supply of water and debris from the upper reaches and the effect of sea-level changes can reach as upstream as over 1 600 km from the river mouth during a rather short period which has never been imaged before.

During the glacial plus low sea-level period, a universal incision was developed as to form a deep channel all through the mid-lower reaches. The bottom of this channel at the last pleniglacial is: lower than-60 m at the mouth, −40 to −20 m at the midlower reaches joint and 0 m at the middle part of Jingjiang segment a. s. l. : the average longitudinal slope is half time over the present one. Even the Three Gorges was also at a period of lower water level, and hence terraces were formed on the previous flood deposits causing the illuvial $CaCO_3$, calcareous concretion to form in the deposits.

During the interglacial when the seal level was high, a universal aggradation happened along the whole mid-lower reaches. The paleo-channels were filled up and flood deposits developed extensively, as to form a great number of mid-channel bars and point bars and the broad flood plains. In tectonic depression area, it covered the previous terraces. The gravel accumulation occurred downcurrent of Three Gorges and flood deposition in Three Gorges.

About the influence of sea-level uprising on the flood deposition, Table 1 lists the variation of the average deposition rates during flood plain period in different regions based on the ^{14}C dating. It is obvious that the fastest deposition time for different segments became younger upcurrent. In the early Holocene, i. e. a period when the sealevel was rapidly rising after glacial, the higher average deposition rate was in the mouth area; whereas in the middle-late Holocene, it was the middle reaches where the flood plain deposition rate was higher. This demonstrates that the influence of the sea-level rising was developing gradually upcurrent. In the Jingjiang segment, the gradual perfection of the artificial dams has slowed down the flood deposition on both sides outside the dams, but the in-channel flood level between dams has been rising and mid-channel bars have been expanding rapidly, showing that the human activities can locally accelerate the natural process towards equilibrium.

Table 1 The Variation of the Average Flood Deposition Rate(m/ka) along the Mid-lower Reaches of the Yangtze River in the Holocene

Age (1 000 a BP)	Jingjiang	Hukou	Anqing	Wuhu	Zhengjiang	River mouth
1		10.5				
2						
3	(8.7)*	13.0	4.1	6.2	1.27	0.76
4						
5						
6						
7						
8					2.62	7.66
9						
10					13.0	
11						
12						

* the 8.7 m/ka is the deposition rate for dam-breaking flood in local ponds(pools), similar to the rate for the in-channel flood level rising in-between the dams along the Jingjiang segment[6].

注 原文：Yang Dayuan. Influence of climate and sea-level changes on the alluvial processes of the mid-lower reaches of the Yangtze river in the last 10 000 years. In: Liu Tungsheng(Edit in Chief). Quaternary Geology and Environment in China. Beijing: Science Press, 1991. 337—342.

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