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The Effect of Geologic Structures on the Control of Floods in the Middle Yangtze River Valley

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Abstract This paper discusses the role of geologic structures in the occurrence of floods and how to prevent flood in the middle reaches of the Yangtze River, and gives the author's suggestion that the Luoshan Qiakou be expanded and the land reclaimed from Dongting Lake be returned to the lake in compliance with the law of geology.

Key words: the middle Yangtze River valley, structures, flood, flood control

1 Structural Factors Affecting the Prevention of Floods

The geologic structures affecting the prevention of floods in the middle the Yangtze River valley, may be illustrated from three aspects:

First, the tectonic framework of the whole the Yangtze River valley is the most important factor. The Dongting-Jianghan area (the middle reaches of the river) is a tectonic subsidence zone and also a plain with a network of rivers and lakes. Both its west and east are upwarped zones, being highland and hilly land respectively. That is to say, the Yangtze River valley is characterized by a landform lower in the centre while higher in the west and east, and the west is the highest area. Therefore, floodwater is easy to pour in but difficult to release from the Dongting-Jianghan area with a network of rivers and lakes. This results in the flood. The author considers that the structural landform is the basic cause for the floods (Wu Shuren and Wu Ganguo, 1999).

Second, the relatively low Dongting-Jianghan area is composed of the Jianghan basin, Hualong uplift and Dongting basin (Zhu et al., 1998). The second-order structural movement in this area resulted in a "see-saw" composed of the northern and southern basins with the Huarong uplift as the fulcrum. Owing to isostatic adjustment, when the northern Jianghan basin uplifted, the southern Dongting basin subsided, and vice versa. For example, there deposited oil-bearing formations of over 3000 metres thick in the Jianghan basin during the Neocene period. At the same time, the Dongting area raised up and became a denuded land. In the Qin and Han Dynasties (before 260 B.C.), the Dongting area was called "Xiaozhu" (meaning a small lake or pond), and Yunmengze (the present Jianghan plain, "ze" means an inundated area) was a large inundated area; during the Tang and Song Dynasties (A.D. 619–1127), Dongting lake greatly expanded, and Yunmengze had become a plain with a network of rivers (Fig. 1). The alternation of the Dongting and Yunmeng basins in sizes between small and large served as an adjustable storage for the "difficult-to-release" floodwater, forming a "natural adjustment system for storage and discharge of floodwater" in the Jingjiang section of the middle Yangtze River valley, Dongting lake and the Yunmengze area. This helped to maintain the balanced development of the environment in the middle Yangtze River valley.

The third factor refers to the structural movement within the Dongting Lake or the Yunmengze area.Take the Dongting area as an example: the uplifting and subsidence were not balanced. According to the study of crustal deformation by the Institute of Geology, Seismological Bureau of China, there are two uplifted zones and a subsided zone (Fig. 2). They are the NW-trending Yueyang-Huarong-Gong'an uplifted zone, the southeastern uplifted zone and the Nanxian-southern Dongting Lake subsided zone respectively. The author classifies the structure in the lake area into

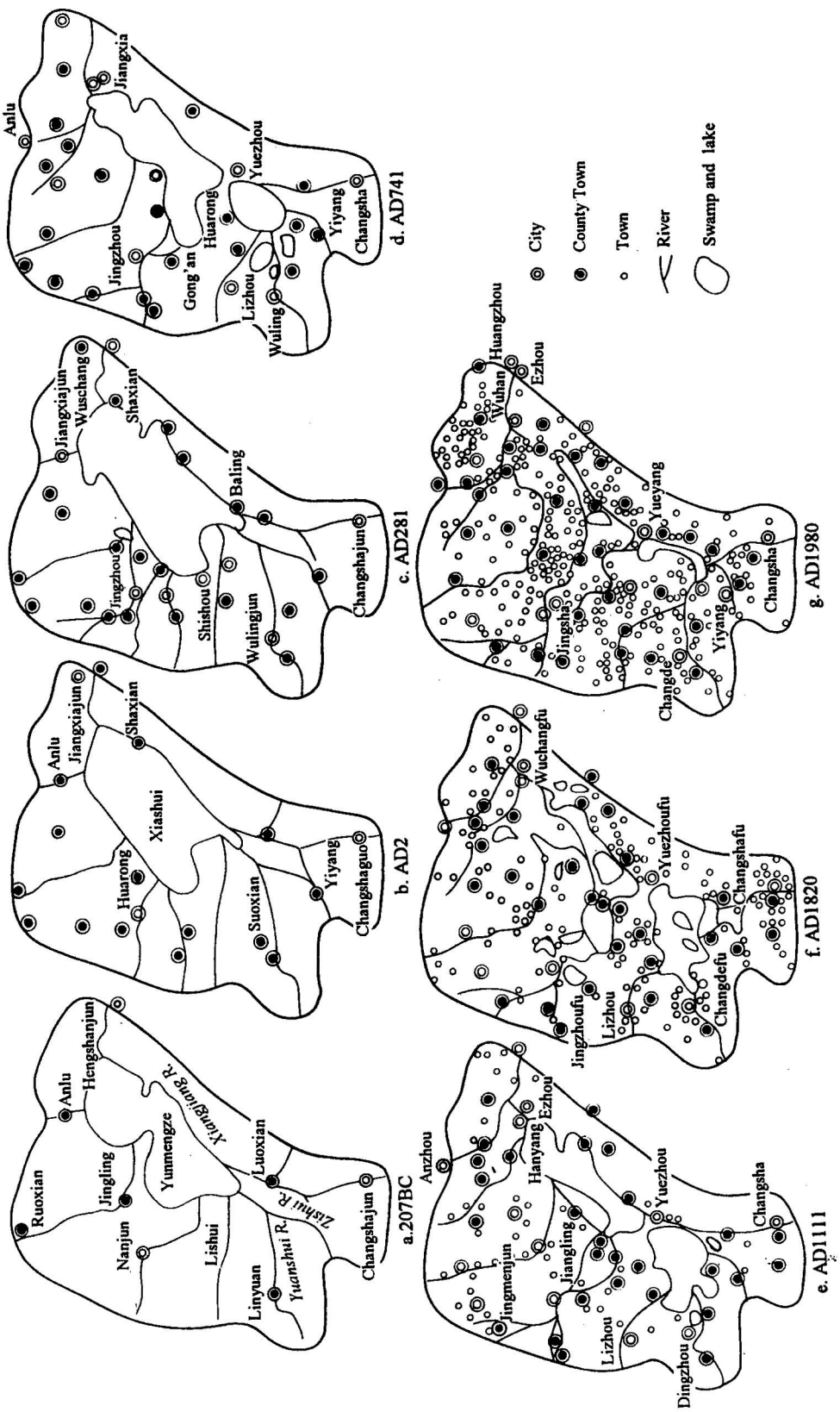

Fig. 1. Historic changes of the distribution of lakes, the Lishui River and cities and towns in the Jianghan-Dongting area.

1. There remained relative size changes in Dongting Lake and Yunmengze from A.D. 207 to 1820, so that a natural adjusting system for storage and discharge of floodwater existed. After that there were no more relative size changes, and the natural adjusting system was destroyed. 2. The Lishui River changed its course from joining the east Yangtze River to the southeast Dongting Lake during A.D. 281 to 741.

the uplifted belt, subsided belt and transitional belt. The transitional belt is named the deformation belt in seismology, and its modern structural movement is more intensive than the other belts. So it can affect the engineering bases of flood control works. As to the uplifted and subsided belts, they are important in guiding floodwater releasing by smashing the dykes, construction of the flood storage area, immigration and building of new towns, establishment of norms for flood control etc. (Hu et al., 1999).

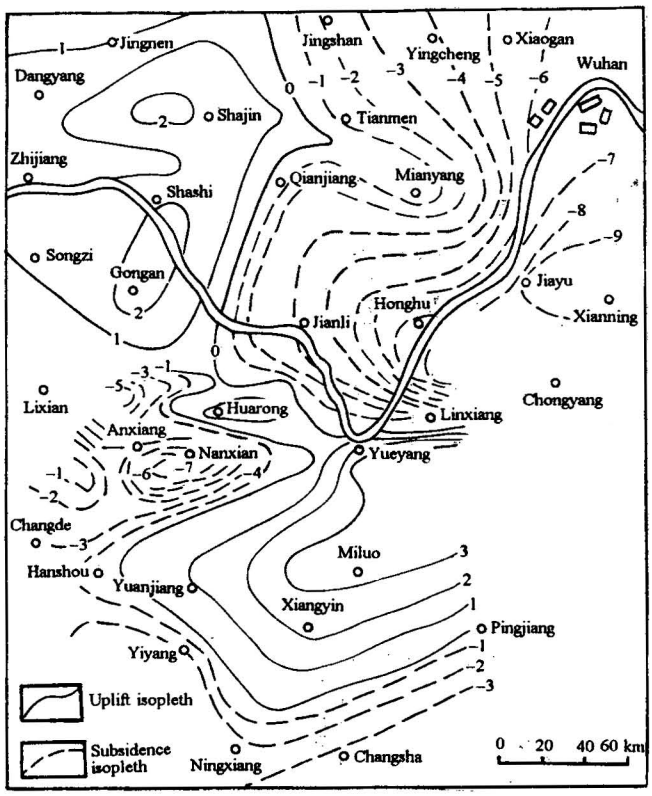

Fig. 2. Vertical deformation of the Jianghan-Dongting basin and its adjacent areas (after the Institute of Geology, State Seismological Bureau).
1. The uplift isopleth (mm); 2. the subsidence isopleth (mm).

2 Geological Basis for Expansion of the "Luoshan Qiakou" And Flood Diversion in Southeastern Hubei Province

The Luoshan Qiakou (meaning a narrow passage in Chinese) is located about 30 km from the lower reaches of Chenglingji, with only a width of 1600 m, while the mainstream of the Yangtze River is 3000–3500 m wide in its upstream and downstream, so it seriously hinders the flow of floodwater. If it can be expanded, the water level in Chenglingji will be lowered and the water discharge will be obviously increased. The expansion of the Luoshan Qiakou is easy to do in technology, but it will inevitably intensify the pressure of flood control in Wuhan City (the largest city in middle Yangtze River valley). Comparing the flood level in 1998 with that in 1954, it is found that it is higher in the Luoshan Qiakou and its upstream but lower in the Wuhan section and its downstream (Table 1). Obviously, it is the Luoshan Qiakou that has affected the floodwater level, which is favourable for the control of flood in the Wuhan section. Therefore, the author suggests that we should take advantage of the geological conditions to expand the narrow passage when we can protect Wuhan City from floods.

The southeastern part of Hubei can be divided into two tectonic elements from Luoshan to Ezhou. The uplifted area in the east is the Mufushan hilly country with an elevation varying from 500 to 700 m; the subsided area in the west is the eastern edge of the Jianghan plain, which is about 40 m ASL. There are many lakes in the area, among which Liangzi Lake is the largest in the Jianghan plain. It is suggested that the western plain is subsiding at present based on the characteristics of the lake that there have developed lake capes, lake bays and a great number of islands. According to the study by the Department of Geography, Nanjing University of China, there was an ancient river in the western plain, which ran from Jiugong Lake to Fankou City. If we can restore the ancient river and use it as a canal for water discharge during the flood period, the menace to Wuhan City by the Yangtze River will never exist any more (Fig. 3). Because we can take advantages of the lakes and the drainage system, the project of restoring the ancient

Table 1 Comparison of floodwater levels (m) at various sections in the Middle Yangtze River valley between 1954 and 1998

Year	Yichang	Zhicheng	Shashi	Jianli	Lianhuatang	Luoshan	Hankou
1954	55.37	50.61	44.67	35.35	33.95	33.17	29.73
1998	54.50	50.62	45.22	38.31	35.80	34.95	27.43
Difference	−0.87	+0.01	+0.55	+1.74	+1.85	+1.78	−0.30

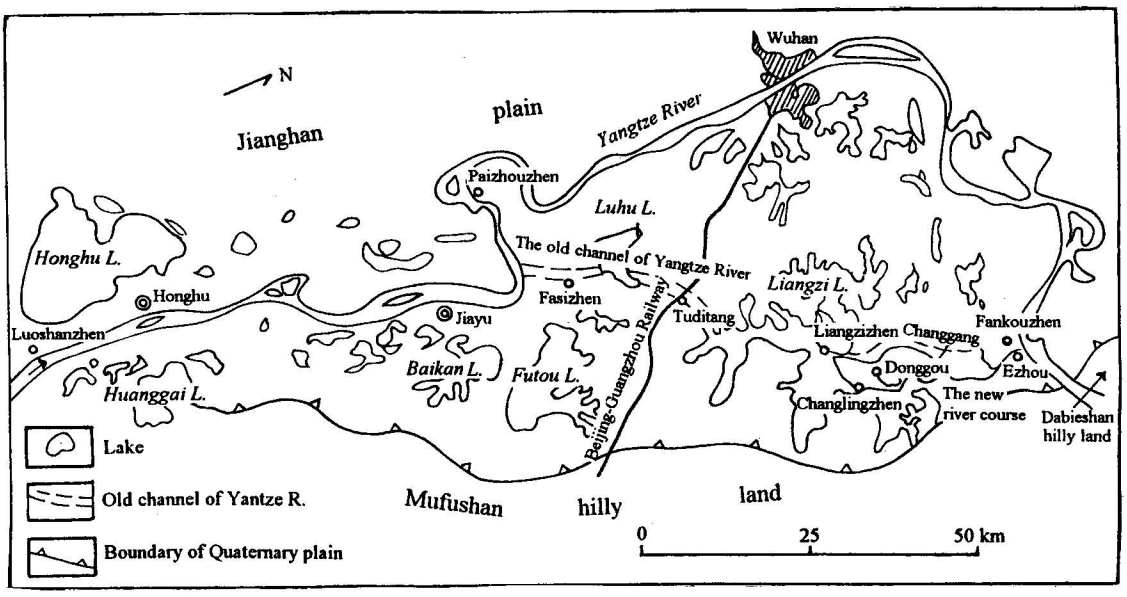

Fig. 3. Distribution of lakes in southeastern Hubei and the old channel of the Yangtze River.

river will not be too much work nor complicated to accomplish (e.g. The distance from Liangzi Lake to the Xingang River is only 100 km). Therefore, this project can be fulfilled without difficulty.

3 Returning the Reclaimed Land to Lakes Based on Geological Laws

Returning the reclaimed land to lakes was one of the measures Premier Zhu Rongji proposed after the disastrous flood in 1998. However, before taking practical measures it is important to study problems such as whether we should return the reclaimed land to lakes, where to return and how much to return is most economical and so on.

Firstly, should the reclaimed land be returned to lakes? As illustrated before, the characteristic landform of the middle Yangtze River valley results in the floodwater "easy to pour in but difficult to flow out", so there must be somewhere to store the floodwater. In history, Dongting Lake and Yunmengze were the places to store floodwater. As their sizes alternated, they composed a natural system of flood adjustment. However, in recent years especially since 1949, out of the lake area of 8000 km^2 remaining from the ancient Yunmengze area 5700 km^2 of land has been reclaimed, and in Dongting Lake only less then 2800 km^2 of land still remains out of the original 4300 km^2. As a result, the alternate changes of area between Dongting Lake and Yunmengze no more exist, thereby destroying the natural system of flood adjustment. Therefore, the author believes that "returning the reclaimed land to lakes" may be a very good measure for resuming the natural system of flood adjustment in compliance with the law of nature.

Secondly, where to return the reclaimed land? The elevation is rising in the Dongting area due to modern crustal movement and reclamation of land; whereas it is lowering in the Yunmengze area. As a result, the Dongting Lake area is much higher than the Yunmengze area. Therefore, emphasis should be put on the latter in "returning the reclaimed land to lakes".

Finally, how much reclaimed land should be returned to the best effect? It is very difficult to answer exactly at present. The author suggests that it should be decided by the following factors: (1) the status of keeping soil from erosion in the upper Yangtze River valley and the construction of reservoirs including the Three Gorges Reservoir; (2) the norms for building the flood-control dams and the capability of flood control; (3) the construction of flood diverting projects in the ancient river channel from Jiayu to Fankou; and (4) the relative uplifting and subsiding limits between the Jinghan plain and Dongting Lake and the period of

variation. Based on the above factors, we can calculate how much land should be returned. Anyway one thing is certain: it is necessary to return the reclaimed land but is not necessary to go back to the status in the year 1949.

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About the author

Tong Qianming Born in November 1941; graduated from Beijing College of Geology in 1964. He is now professor and chief geologist of Hunan Institute of Geology, and has been engaged in studies of economic geology, environmental geology and agricultural geology for 36 years, with 5 monographs and 80 papers published.