

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

185,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Neo-tectonic Movement in the Pearl River Delta (PRD) Region of China and Its Effects on the Coastal Sedimentary Environment

Yuanzhi Zhang, Zhaojun Huang, Yu Li, Qing Yu, Bing Wang and
Tingchen Jiang

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/61981>

Abstract

This chapter presents the Late Quaternary neo-tectonic movement in the Pearl River Delta (PRD) region of China and its effects on the coastal sedimentary environment. Taking the Xilin Hill fault as the example, we have explained the reason of the PRD formation, inferred its interactions with local/regional climate and sea-level changes, and analyzed the evolution of the PRD formation and its controlling factors of the coastal sedimentary environment.

Since Late Quaternary, the intense change of coastal sedimentary environment in the PRD region has resulted in accumulating the thick sedimentary layers with the different causes and properties which were influenced by the fluctuation of sea levels, the change of ancient climate, and human activities. Based on the interpretation of high resolution of these sediments, such as the period, sedimentary facies, and discontinuous facies, we can infer the evolution of the ancient climate of regional Quaternary environment in the background of global change to know more details about the formation of the PRD. It is noted that the neo-tectonic movement and the fault activities played a critical role in controlling the coastal geological environment. This is helpful to further investigate the evolution of the PRD coastal sedimentary environment, the history of the inversion region, and the sedimentary facies model of the interaction between land and sea. More investigations will be conducted in the near future.

Keywords: Neo-tectonic movement, Pearl River Delta, Quaternary geology, coastal sedimentary environment, sea-level change

1. Introduction

It is an important question for discussion of coastal geomorphology [1] to study the coastal sedimentary environment and the impact from the Quaternary neo-tectonic movement in river estuarine-coastal regions, such as the Pearl River basin. Pearl River Delta (PRD) is a dynamically evolving landform that occurs at the mouth of Pearl River systems where the sediments are deposited as they are moving to South China Sea (SCS). There are several controlling factors accounting for the formation of the PRD, including neo-tectonic movements, sea-level changes, fluvial processes, and human activities (e.g., [29, 30]).

The PRD Quaternary environment is an important topic in response to global climate change, as it has a complicated environment, in which the PRD is located in the special position of the transition of land-sea, sensitive to the climate change and sea-level rising [29].

A number of previous studies investigated the PRD region and made a great achievement, including the deposition, new tectonic movement, fault activities, sea-level changes, and ancient environment evolution. For example, the relationship between several activities of the fracture structure and river terraces by the causes of the block tectonic geomorphology in the PRD was first proposed and discussed in the early 1980s (e.g., [12, 30, 31]). Later on, the amplitude and rate of fault block tectonic movement were reported by applying the results of the dating of Quaternary sediment chronology since Quaternary period (e.g., [2]). However, it was addressed to analyze the characteristics of the fault block tectonic movement and the dynamic tectonic stress field since Late Tertiary (e.g., [6, 33]). In addition, the crustal stability of several districts in the PRD region was analyzed by using geochemical testing results (e.g., [28, 34]).

From the detailed information of sediments, the environmental history of the sedimentary sequences in Late Quaternary can be reconstructed to understand the evolution of the ancient climate of regional Quaternary environment in the background of global change and to infer the changes of global climate and sea-level rising (e.g., [29]). In a word, the Quaternary geology of the PRD region is of great significance.

In regard to the causes of the formation and development of the PRD since Late Quaternary, it is still being an academic controversy. Some researchers believe that the development of the PRD was mainly influenced by rising sea level, or caused by Lushan glacial and postglacial climate changes. In comparison, the others believe that the climate fluctuation did not change too much during Lushan glacial and postglacial, as the amplitude of fluctuation is only a few meters to tens of meters since 30 ka B.P. (B.P. means before present where “present” represents 1950) in the north of South China Sea. However, a number of SCS transgressions since the postglacial period had provided the necessary condition for the development of the PRD (e.g., [13, 16, 18, 19, 26]). Nevertheless, there are some issues to be further investigated. For example, there are two kinds of disparate opinions about the age ascription of the lower cycle. One is that the lower cycle may be dating back to about 30,000–40,000 years, while the other is that it may belong to the period of about 100,000 years more or less.

In recent 20 years, advanced techniques such as interferometric synthetic aperture radar (InSAR) and differential synthetic aperture interferometry (DInSAR) have been widely applied to construct digital elevation models of the earth's topography and to image centimeter-scale displacements associated with crustal deformation and the flow of ice sheets. As a result, coastal geomorphology can also benefit from these techniques [23]. In particular, such techniques have made a great progress in the application of coastal geomorphology to interferometrically measure centimeter-scale motions associated with unstable slopes, land subsidence, fluctuating soil moisture, and water levels [20].

In this chapter, we first review the neo-tectonic movement in the PRD based on the theory of Quaternary geology, then analyze the reason of the PRD formation and its controlling factors, which integrated the results of the deposition, sea-level changes, fracture, and fault block, and finally discuss the effects on the PRD coastal sedimentary environment.

2. Study area

The Pearl River Delta region is located at 21°20'–23°30'N and 112°40'–114°50'E, Guangdong Province, South China, which was formed in the past 9000 years [16, 17]. It is one of the fastest developing regions in China and experiencing a rapid rate of economic growth. As it is shown in Figure 1, Pearl River flows through the PRD and then into the South China Sea. In recent years, it is one of the most densely urbanized regions and one of the main hubs of China's economic growth.

The length of the Pearl River is 2214 km, and the drainage system of the Pearl River covers about 425,700 km² (e.g., [17]). But the area of the receiving basin is 9750 km², which includes the deltaic plains, the estuary, and rocky islands but excludes the area of Hong Kong [11].

The Pearl River consists of three major sub-rivers, namely the East River (or Dongjiang), the North River (or Beijiang), and the West River (or Xijiang), which flow into the Pearl River estuary (PRE) before inflowing the South China Sea. The flat lands of the delta are crisscrossed by a network of tributaries and distributaries of the Pearl River system. The PRD is actually two alluvial deltas, separated by the core branch of the Pearl River. The North River and the West River flow into the South China Sea and Pearl River in the west, while the East River only flows into the Pearl River proper in the east [17].

The PRD belongs to the East Asian monsoon region and the climate is low subtropical. The temperature of the delta area is relatively high, with the average temperature of the whole year varying from 21.5 to 22.5 °C. The highest temperature is 38 °C during the past years, but the minimum temperature occurs every 10 years, low to 0 °C. In addition, the rainfall is abundant, with the average annual rainfall of 1600 mm or more. However, during the dry seasons, the distribution of rainfall is not even. The main modern natural vegetation includes evergreen broad-leaved forests, coniferous forests, grass slopes, mangroves, etc. [11].

Due to the uplift of Tibetan Plateau, the PRD was formed during Tertiary and Quaternary. Its active fault systems developed as a result of the land subsidence of the receiving basin during

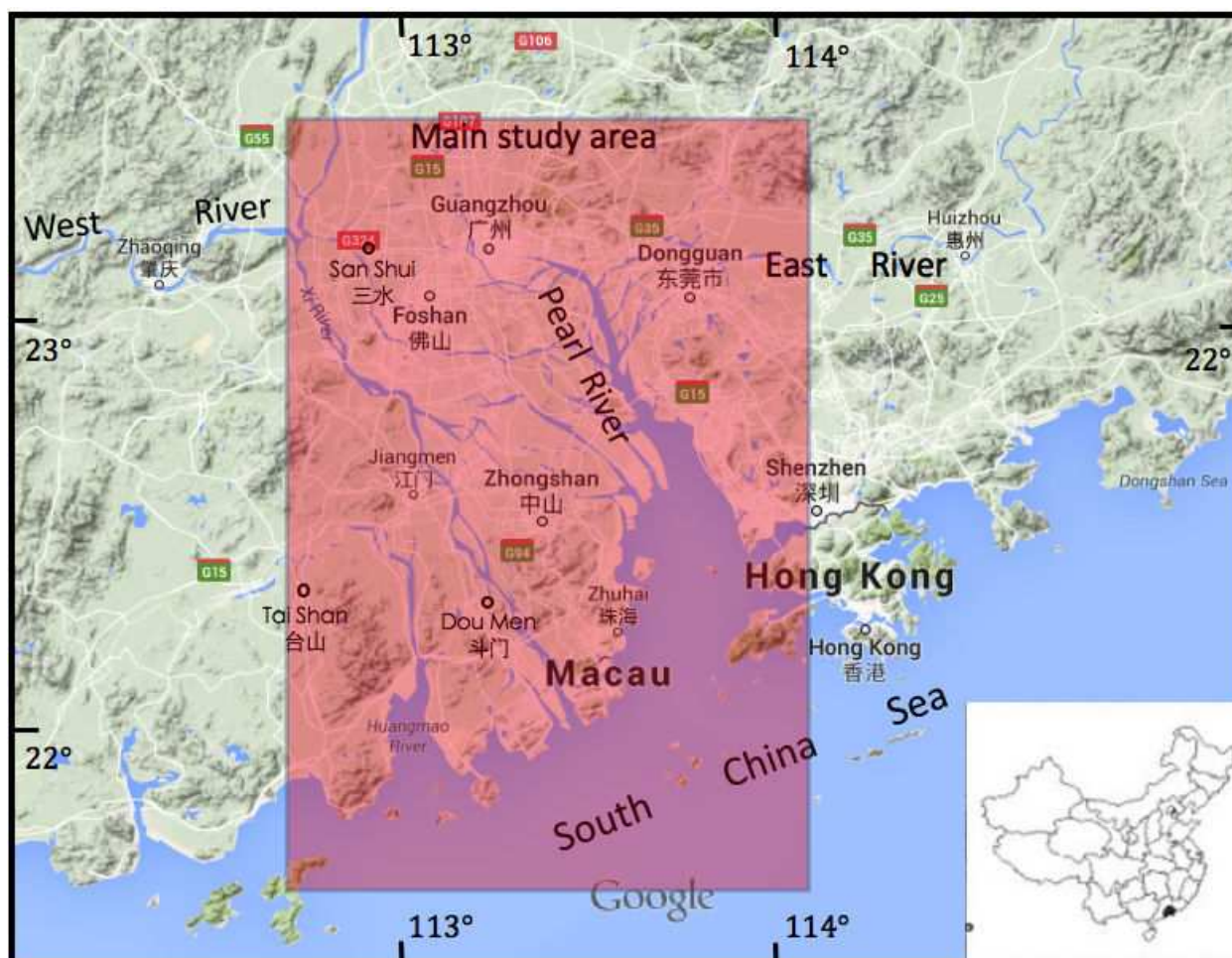


Figure 1. The study area of the PRD region (courtesy of Google Maps as the background of the PRD region).

Late Quaternary. A number of valleys were disconnected by rocky islands and several hills. In the lower reaches of the East River, there is a shallow paleo-valley with the depth of 30 m. Meanwhile, two paleo-valleys with the depth from 30 to 40 m are found in the North River and the West River. When the three paleo-valleys crash into the southeastern basin, they are merged. At that time, another separate paleo-valley was formed in the southwestern basin [16, 17].

The PRD geomorphological characteristics with more than 160 island bumps on the plain are represented by several geomorphic types, such as hills, platforms, and monadnocks. Its area accounts for about one fifth of the whole delta area. In recent times, there are hundreds of islands distributed in the waters of the Pearl River estuary, with the altitudes varying from 100 to 300 m [13, 14, 15].

As the deposition rate of the delta estuary and coastal waters was relatively high, a great of geological information was recorded in deep layer sediments. The sedimentary information is important for analyzing the reason of the PRD formation and controlling factors, which integrated the results of the deposition, fracture, and fault block, and discussing the effects on the PRD coastal sedimentary environment.

3. Methodology

The methodology of this research includes traditional geological survey and applications of advanced techniques. Hence, we applied stratigraphic and sedimentary analysis, carbon dating, and InSAR and DInSAR techniques in the PRD investigation. By interpreting the high resolution of sediments, the detailed information, such as the periods, sedimentary conditions, sedimentary facies, and discontinuous facies, and sequential relationships between the strata can be obtained [2, 29].

Radiocarbon 14 (^{14}C) dating is a common means for chronological divisions. The dating principle is that after the carbonaceous materials died, the carbon in the body could stop exchange with the outside world. Then the content of ^{14}C is reduced by the rate of decay. On comparing the residual content of radiocarbon 14 samples with that of present similar samples, we could deduce the epoch from the time after exchanging ^{14}C . As the half-life period of ^{14}C is 5568 years, it will be reduced by about 1000 times after 10 half-life periods [2, 9, 29]. So the modern radioactive detector almost cannot work. Considering these conditions, the ^{14}C dating method is suitable for carbonaceous materials dating back to 300–50,000 years. As the precision is about 1–2%, the older the sample, the greater the error is [25].

4. Results and discussion

4.1. Structure characteristic and faults distribution

PRD is located within the Eurasian Plate, adjacent to the oceanic crust of South China Sea. It is subjected to the extrusion in different directions of Philippine Sea Plate and Indian Ocean Plate. The PRD tectonic stress field is mainly affected by the pushing of the South China near south-north. The PRD fault depression originated in the Cretaceous and continued to the inherited activities in the basin of Quaternary (e.g., [7, 12, 30, 32]).

As a result of a series of crustal movements, the fault structure and fault basin were formed, namely fold: syncline structure and anticline structure. The PRD basal strata are old, which is mainly composed of metamorphic rocks of Sinian and Paleozoic eras. The metamorphic rocks of Sinian are distributed in northern and eastern parts of the delta, whereas those of Paleozoic are found in the periphery of the delta. Granites intruded when the Yanshanian movement occurred from Jurassic to Cretaceous. More important is the foundation of the topographic outline of the ancient gulf. With the invasion of granites and fault activities, the fault block mountain and fault basin developed rapidly (e.g., [30]). After the erosion and eroding, fault blocks were turned into hilly and mountainous lands. The fault basin was developed by accumulating the materials of mountain erosion. Consequently, there existed the hilly land and marine strata composed of volcanic rocks with the volcanic activities and marine transgression. Later on, the delta basin was uplifted to lands and endured erosion and incision during the Middle Tertiary period when the crust changed rapidly by the Himalayan movement [7]. After that, the materials from erosion and eroding were carried to the place which is

far away from the PRD, more than 200 km. During the Late Tertiary period, several delta basins were rifted by the fault block movements. When it came to Middle–Late Pleistocene of Quaternary, the delta experienced a depositional phase. At that time, the plain areas were subsided, but fringe areas were uplifted [12]. Under the combined effects of fault block subsidence and sea-level changes since the Quaternary, the depression within the rifts usually formed two sets of delta-accumulated strata, with the large range of distribution and thickness of sediments [3, 32].

The PRD has three groups of main striking fault systems, namely northwest (NW), nearly east–west (EW), and northeast (NE) faults. By the analysis of the characteristics of seismic risks in the PRD, it is suggested that these three groups jointly cut these fault blocks into seven sub-fault blocks [3, 12, 30, 33] as shown in Figure 2. Although the formation times of the three group faults are different, EW and NE faults were formed earlier than the NW faults in the Yanshanian movement. Delta basal unit was also cut into several fault blocks with different sizes and velocities as the interaction of the three groups of these faults [78]. In Figure 2, the fault blocks (I–VII) and faults (1–13) are summarized and described as [12, 30, 31, 33]: I Dongjiang Delta fault block, II Tan Hoi fault block, III Wuguishan fault block, IV Shiqiao–Guangzhou fault block, V Xijiang–Beijiang Delta fault block, VI Pearl River estuary fault blocks, and VII Near-shore SCS (South China Sea) fault block, while the faults are named as:

1. Sanshui–Luofushan Fault,
2. Guangzhou–Conghua Fault,
3. Dongguan–Houjie Fault,
4. Shiqiao–Xinhui Fault,
5. North foothills of Wuguishan Fault,
6. South foothills of Wuguishan Fault,
7. Shenzhen–Zhuhai Fault,
8. Near-shore shallow water of PRE Fault,
9. Xijiang Fault,
10. Baini–Shawan Fault,
11. Nangang–Humen Fault,
12. Hualong–Huangge Fault, and
13. Yamen Fault.

As shown in Figure 2, among the fault blocks mentioned above, the fault blocks from I to IV were mainly controlled by northeast faults. Fault blocks (I–IV) were developed into the Dongguan basin and the Xinhui basin, which were formed before Quaternary. The delta sedimentary facies were filled with the two faults by about 20–30 m deep. During the Yanshanian movement, crystalline rocks were broken along the northeast trending and invaded

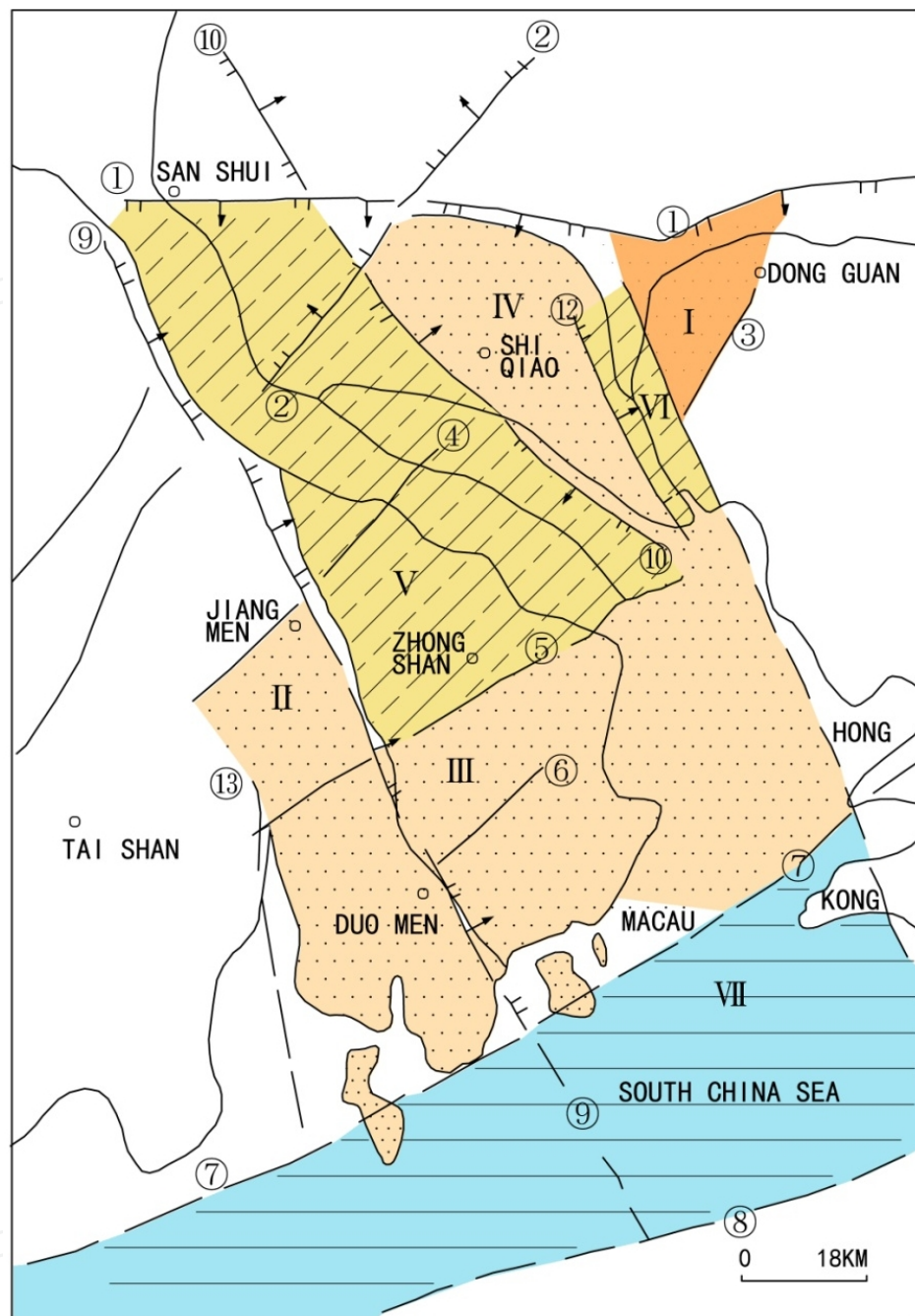


Figure 2. The schematic diagram of the fault blocks in the Pearl River Delta (summarized and courtesy of [7, 12, 30, 32, 33].

into the raised rear part of Wuguishan. According to the study of radioisotope dating, three group faults moved vertically at the rate of less than 1 mm/year since Late-Pleistocene, and thus the main faults had not obvious signs of active tectonic dislocations [4, 24].

The north of striking fault block IV is principally controlled by Sanshui–Luofushan fault, while Baini–Shawan and Hualong–Huangge faults are in control of the south of this fault block. Among them, it is said that Sanshui–Luofushan and Baini–Shawan faults had obvious active tectonic dislocations during Early-Pleistocene, but there was no dislocation in Late-Pleistocene.

Until Late-Pleistocene, the Pearl River's development was operated by Sanshui–Luofushan and Hualong–Huangge faults [6, 32, 33].

Fault blocks V and VI are controlled by the NW faults. The fault blocks are subjected to the incision of the NE faults. Among the two sets of faults, the former has the feature of normal faults, while the latter has the feature of reverse faults. The tectonic geomorphology was well developed, including the northwest trough and valley, as well as the northeast ridge. The thickness of Quaternary sediments varies from about 40 to 50 m, while some parts may be up to 60 to 70 m. However, there is a huge difference in south and north. Usually, the thickness of the northern PRD is less than 40 m, even that the weathering crust in large areas gave a push up by several meters to about 100 m from Early Quaternary. At that time, the southern weathering crust was buried with several meters. It is clear that that the activity of faults in north is much weaker than that in south (e.g., [32]). Fault block VII is controlled by the northeast faults and is also cut by the northwest faults. The thickness of Quaternary trough and valley can be up to more than 50 m. According to the estimation of radioisotope dating, the sedimentation rate of fault block VII is up to 3 mm/a in middle–late Pleistocene. The activities with high sedimentation rates and fracture rates lasted for a long time during Late Quaternary. It is evident that the activity of this fault block is stronger than the other six. Moreover, the fault is dating back to 30,000–40,000 years, indicating that its formation period is young, and thus the activity of fault block VII is relatively new (e.g., [32, 33]).

Due to the different activities of the fault zones since Quaternary, the intensity of the seven fault blocks is also different. According to the regulations of South China coastal seismic belt seismicity, the various seismic risk regions of PRD can be divided into three grade areas, that is, the activity of South China Sea fault is intense, while Xijiang fault, Beijiang fault, and estuary fault are posterior and also weak [6, 33].

4.2. Neo-tectonic movements

To a certain extent, tectonic movements affect the distribution of sediments, which is the result of the tectonic movements. As PRD is located within the continental plates of Guangzhou in South China, the average thickness of crust is about 28–30 km. According to the speculation, it was caused by the upburst of upper mantle with a high density. As a result, the neo-tectonic movement has inherited the tectonic framework since Yanshanian movement. Several borders of the PRD region are controlled by NE tectonic movements. On the other hand, the activity of NW tectonic movements dominated the trend of sedimentary geomorphology. Tectonic lines of the above two groups jointly manipulated the pattern of tectonic geomorphology in that the direction of NW is as the long axis and the direction of NE is as the short axis (e.g., [2, 6]).

It is acknowledged that in the tectonic uplift areas, the higher the landform is, the older the stratum is. However, in the tectonic subsidence areas, the lower the sedimentary layer is, the older the stratum is, and each new layer is laid down horizontally over older ones in a process [2, 6, 21] as shown in Figure 3.

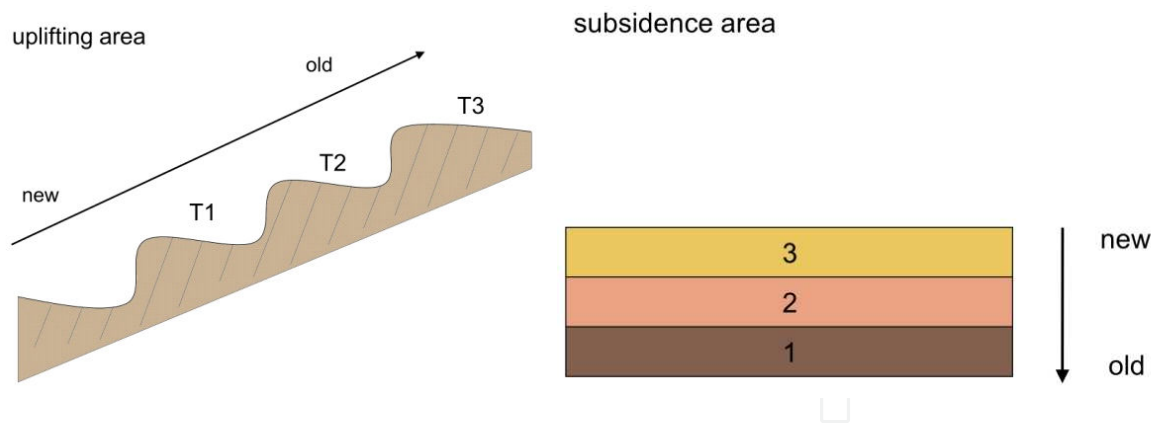


Figure 3. Ages sketch map of sediments in the uplifting and subsidence areas.

There is no doubt that the upper cycle of two sedimentary cycles in PRD belongs to Holocene, and the lower one is dating back to Late-Pleistocene [35, 36]. By analysis of the PRD sediments, it is suggested that there has existed two progressive cycles since Late-Pleistocene. However, there is no consensus about the epoch ascription of the lower cycle. If it is dating back to about 30,000–40,000 years, it should be middle–late Late-Pleistocene (i.e., MIS3). But it should belong to early Late-Pleistocene, if it is dating back to about more than 100,000 years (i.e., MIS5).

According to the previous investigation, the sea level of MIS3 was about 50 m lower than the current level. However, the average thickness of the PRD sediments in Quaternary is only about 30 m. Therefore, in theory, it is impossible that there was deposition only during MIS3. It is inferred that the lower cycle may be dating back to about 120,000 years, belonging to MIS5 (e.g., [22, 29]).

Although the PRD region is located in the continental margin of the north of South China Sea, compared with other continental margins, there is no volcanic activity but weak seismic activity. Consequently, the crust is relatively stable. But the region is influenced by the expansion of South China Sea. The faults developed in the coast of South China, especially the basement faults with the NE and near EW directions. As the PRD is cut by the faults and formed several fault blocks with different movement directions and velocity, the neo-tectonic movement of the PRD is characterized by the fault activities and differentiated movements of these fault blocks [6, 30, 33].

In addition, the tectonic movement has a great significance in the development of PRD. The delta was cut into a series of fault blocks by the basement faults which developed or reactivated during Quaternary. These fault blocks were dominated by subsidence in the vertical movement, moving at different directions and rates, which provided accommodation for Quaternary sediments. As a result, the evolution process of PRD was mainly controlled by the faults since a lot of evidence has been found from the distribution of Quaternary sediments, drill holes, and geologic profiles (e.g., [7, 33]).

According to the different distribution of fluvial gravels developed since the first marine transgression in Late Quaternary, it is obvious that the paleo-drainage patterns have been greatly changed as a result of fault activities (e.g., [12]). In short, during the PRD formation

and evolution, neo-tectonic movements not only influenced its sediments but also controlled the river channel changes.

4.3. A case study of neo-tectonic movements at Xilin Hill

According to the previous studies, it was found that the Late Quaternary layers were uplifted, tilted, and faulted (e.g., [33]). These layers are located at the Xilin Hill, between Guangzhou and Foshan, in the north of PRD. On the south of the Xilin Hill, the Holocene black carbonaceous mud of the depth about 2 m was intercalated with sands. It is found that it contains Chinese cypress old tree, covering on vermiculated laterite weathering granite [8, 33]. This implies that the strata contain not only the information of faulting but also the records of neo-tectonic movement, sea-level changes, and paleo-environmental changes in the north of the PRD region.

Xilin Hill is located in the east of Guangzhou–Conghua fault and the west of Baini–Shawan fault. The bottom of Xilin Hill is covered with the granites but the top is covered by the residues of red soil and Quaternary sedimentary soil. Meanwhile, the Quaternary is distributed in the slope southeast of Xilin Hill, in which the middle layer of soil layer deposition is greater than 3.5 m. Among them, the fourth layer was dating back to 40,000 years.

Xilin Hill fault with NE direction is referred to the cross section on the western mountain of Xilin Hill, which directly cuts the Quaternary sediments. It is found that the fault not only cuts Quaternary stratum but also that two sets of sedimentary layers of Quaternary are an angular unconformity (e.g., [33]). The fault strikes 30° and trends NW with the inclination of 72° . That is, a normal fault with the maximum distance of 53 cm.

According to the preliminary study, the strata can be divided into four parts from old to new as layers A, B, C, and D (e.g., [32, 33]) as given below:

Layer A: The grayish white sands are filled with the lower part of the layer. It goes up to the gray and black clay. This layer contains humus. The phenomenon of soil gasification is obvious. In the top of the layer, the limonite shells were developed intermittently. The depth of limonite shells varies from 1 to 2 mm. The whole depth of this layer is 50 cm or more. Moreover, the granites were vermiculated and undergo laterization.

Layer B: The grayish sand and brownish clay are alternated with the total thickness of about 4 m. The coarse sands and fine gravels are surrounded by black clays with the depth of 60 cm. The gray clay and coarse sand and fine gravels are alternated. The top is covered with the silty clays. Meanwhile, the top of orange-red coarse sands is covered with peat layers. There are some brick-red middle coarse sands in this layer which are not weathered. The thickness of each sub-layer varies from 30 to 40 cm.

Layer C: This layer is covered with poor bedded light orange coarse sands and fine gravels. The maximum diameter of the gravel is 0.5 m. However, the bedding is not developed in this area. The slope sediments are better developed.

Layer D: the fourth layer is modern sediments, dating back to 40,000 years.

The thickness of A, B, and C is more than 10 m. Layer A and layer B were tilted southward. However, the inclination angle is different. The inclination angle of the former one is about 30° but the latter one is about 4° . Although layer B is covered over layer A, the two layers show an angle unconformity (e.g., [8, 32, 33]). It is evident that a long hiatus occurred between the two layers. Additionally, there are modern gullies and slope sediments, which embedded layers A and B. These three layers make up the pedestal terrace with the height about 22 m. As in Figure 4, there exist cutting and superimposed relationship between layers B, C, and D [33].

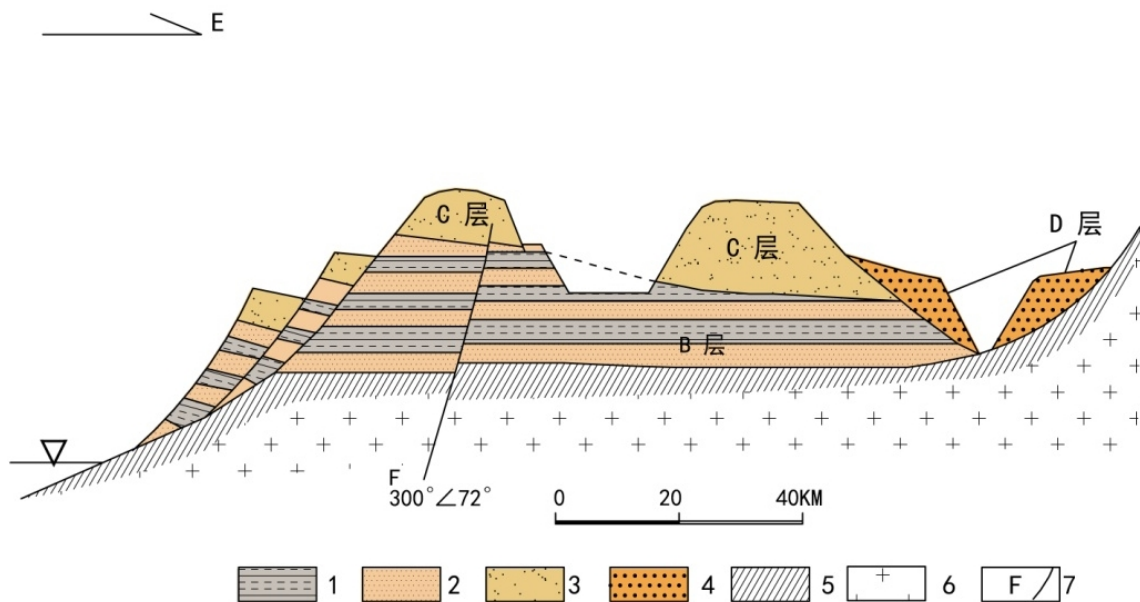


Figure 4. Section of the Late Quaternary pedestal terrace at the Xilin Hill in the north PRD (summarized and courtesy of [8, 33].

Figure 4 also shows the slope sediments of Holocene (layer D). The pedestal terrace is composed of the granites since Late Yanshanian period, making up of layers B and C. It is clear that layers A, B, and C are formed as the pedestal terrace in the elevation of 7 m. The height of the sediments of the pedestal terrace is about 22 m.

As seen in Figure 4, layer B is cut by a fault. The strike of fault is 30° , the inclination angle is 72° , and the tendency is northwest. The side structure suggested that there was some displacement as a result of dextrorotation, which is the dextral normal fault, as the upper side of the fault coasted down with several centimeters [8, 32, 33] as shown in Figure 5.

Here, the Late Quaternary pedestal terrace at Xilin Hill shown as in Figure 4 can be summarized and described as 1, clay layer; 2, sand layer; 3, sand and gravel layer; 4, gravel layer; 5, vermiculated laterite weathering crust; 6, granites of Late Yanshanian period; and 7, faults.

As shown in Figure 5, it is obvious that the layer B is cut by a fault. The fault is the eastern branch of the Guangzhou–Conghua fault, in which the upper plate slides down. When the fault incised upward to the layer C, it was bifurcated, with decreasing amplitude and occur-

rence changes. The period of the fault activities may be dating back to the Late-Pleistocene. According to the compared ages of vermiculated laterite weathering crust and other adjacent similar river terraces, the age of layer B should be dating back to the late Middle-Pleistocene to the early Late-Pleistocene [8, 32].

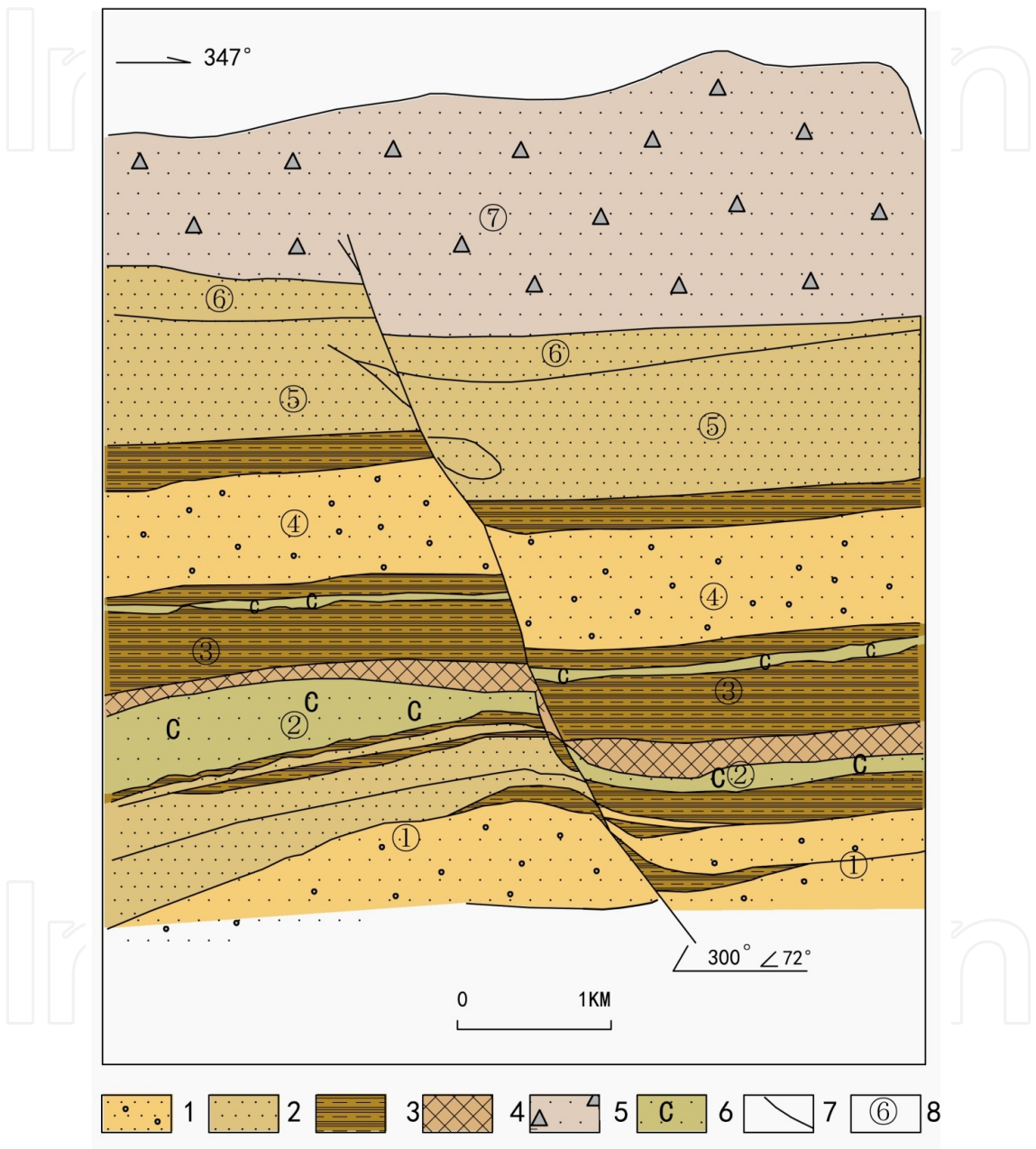


Figure 5. Sketch map of Pleistocene offset fault at the Xilin Hill in the northern PRD (summarized and courtesy of [8, 32].

There existed a fault with the direction nearly EW in the south of Xilin Hill, forming the obvious boundary between the hilly in the north and the PRD plain in the south. The peat mud layer of Holocene is found in the south of this fault. Gray thin layer of sands is covered with the black carbonaceous mud, which contains a large number of cork and Chinese cypress ancient

trees and covers on the vermiculated laterite weathering granite. In the lower place, vermiculated laterite weathering crust appears [32, 33].

Here, the Late Quaternary pedestal terrace at Xilin Hill as shown in Figure 5 can be summarized and described as 1, sand gravel; 2-coarse sand; 3, clay; 4, silty clay; 5, slope sediments of sand and gravel; 6, carbonaceous mud; 7, fault; and 8, number of layers (1–6: layer B and 7: layer C).

The fault of Xilin Hill is within the range of maximum value of gravity anomaly in the PRD. The fracture dislocation and fault movement caused by the fault are connected by the deep faults. In general, there occurred transgressions twice in PRD since Pleistocene.

As the PRD is a fault block delta, the evolution of this delta accounts for several factors, including fault block movement and discrepant movement between the fault blocks and fault activities. Based on the development of vermiculated laterite weathering crust below the layer A, it is thought that the PRD region had been subjected to a long weathering before the deposition of Quaternary. Moreover, layers B and D may correspond to the first and the second transgressions, respectively. The entire evolutionary process is recorded perfectly from layer A to layer D [32]. Therefore, three sedimentary layers above the pedestal terrace not only contain the information of fault activities but also reflect the significant relationship among the changes of sedimentary facies, the migration of ancient rivers, and neo-tectonic movements. The important information mentioned above provides the basis for studying the formation of the PRD. In addition, it plays an important role in civil engineering construction, urban planning, and geo-hazard prevention in the further study.

4.4. The PRD sedimentary environment

Sedimentary facies are the sediment bodies combined with a certain characteristic of lithology, texture, structure, and paleontology signs, reflecting the depositional environment at that time [5, 10, 13, 19, 26]. In general, the sedimentary facies are a comprehensive reflection of the sediments and their sedimentary environment. The sedimentary environment not only controls the texture, structure, and compositions of sediments, but also affects the distribution and combination of fossils of plants.

Thus, the study of sedimentary facies is the foundation of recovering the sedimentary environment, and is also an important base for stratigraphic divisions. The sequence of the PRD sedimentary facies is divided into four major environments (e.g., [19]), namely delta plain, delta front, tidal estuary, and shallow-sea shelf (Figure 6).

As shown in Figure 6, the PRD sedimentary environment can be summarized and described as follows:

1. I delta plain

Delta plain (I) is the part of land, which is the district between the trend line of dry seasons and modern shoreline. There are several platforms and more than 160 monadnocks in the Pearl River Delta plain. The river network developed well and branches of water channels were interwoven into the network. There are more than a hundred of water channels with the length

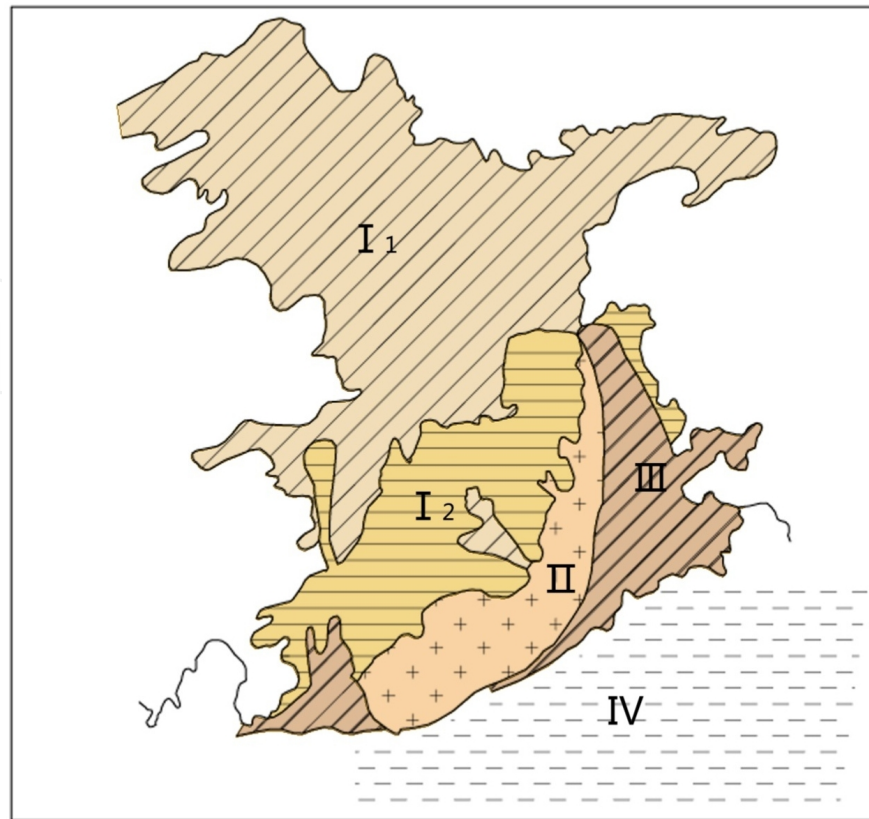


Figure 6. Sketch maps of recent sedimentary environments of the PRD (I delta plain, II delta front, III tidal estuary, IV shallow-sea shelf) (courtesy of [10, 19].

of about 1700 km. Meanwhile, the delta plain can also be divided into two parts: the upper delta plain (I₂) and the lower delta plain (I₁). The upper delta includes distributary channel, distributary depression, and floodplain, while the lower delta includes distributary channel and floodplain.

2. II delta front

Delta front (II) is usually formed as a result of the interaction of sea and river, including estuary dam, natural levee, front slope, distributary gulf, and shallow ford. In this area, therefore, the activity of the deposition is the most, and further on, the river sediments shall be once more superposed and distributed to cause more complicated types of sediments and sedimentary structures.

3. III tidal estuary

Tidal estuary (III) is mainly influenced by the tidal action. The related depositions are tidal channel, tidal dam, tidal shallow ford, lower tidal plateau, and upper tidal plain.

4. IV shallow-sea shelf

Shallow-sea shelf (IV) is distributed in the 30 m depth of estuary, which are rich in organisms of shallow sea and mollusks. In addition, the content of organic matter is very high (about

1.5%). The sediment is gray silty clay in the northern part. But due to the wave erosion, these sediments are being coarsened to be mixed with sand, silt, clay, and/or fine sand [10, 19].

5. Conclusions

In this chapter, we present the Late Quaternary neo-tectonic movement in the Pearl River Delta region of China and its effects on the coastal sedimentary environment. By the example of the Xilin Hill fault, we gave the reason of the PRD formation, inferred its interactions with local/regional climate and sea-level changes, and discussed the evolution of the PRD formation and its controlling factors of the coastal sedimentary environment [8, 10, 19, 32]. Thus, some conclusions can be summarized as below:

1. According to the analysis of sedimentary facies and carbon dating, the PRD evolution process since Late-Pleistocene (about 40 ka B.P.) can be divided into three stages called as pre-deltaic (40–32.5 ka B.P.), paleo-deltaic (32.5–7.5 ka B.P.), and neo-deltaic (7.5 ka B.P. to present).
2. Quaternary sedimentary layers of the PRD region in the vertical stacking sequence are such a positive sequence that the lower is coarse-grained, while the upper and middle is fine-grained.
3. Based on the study of the modern sedimentary environment, the Pearl River runoff and estuarine current interact to promote the formation and development of the delta.
4. Due to the different activities of the fault zones since Quaternary, the intensity of the seven faults is different from each other. The activity of South China Sea fault is the greatest, while Xijiang fault, Beijiang fault, and estuary fault are posterior and also weak (e.g., [32]).
5. The neo-tectonic movement plays a significant role during the evolution of the PRD. It not only controlled the changes of river channels but also influenced the sediments of delta. The two stages of gravel stratum with fluvial facies are represented by the location of the ancient valley before the two transgressions. However, the difference of distribution of gravel stratum with fluvial facies could reflect that the changes of river channels between the first transgression and the second one as a result of the fault activities.
6. The Xilin Hill fault revealed many important and basic issues in the changes of Late Quaternary environments, neo-tectonics, and fault activities (e.g., [32]).
7. There are several controlling factors for the PRD formation, including sedimentary evolution, the Quaternary ice age, sea-level changes, and human activities.

In the near future, more investigations will be conducted for the further study of the Late Quaternary neo-tectonic movement in the PRD region of China and assess its effects on the coastal sedimentary environment.

Acknowledgements

This research is jointly supported by the “2015 Jiangsu Program for Innovation Research and Entrepreneurship Groups, China”, the National Science Foundation of China (41271434), and the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD).

Author details

Yuanzhi Zhang^{1,2*}, Zhaojun Huang², Yu Li², Qing Yu², Bing Wang² and Tingchen Jiang³

*Address all correspondence to: yuanzhizhang@cuhk.edu.hk

1 School of Marine Sciences & Jiangsu Research Center for Ocean Survey Technology, Nanjing University of Information Science and Technology, Nanjing, Jiangsu Province, China

2 Center for Housing Innovations, the Chinese University of Hong Kong, Shatin, Hong Kong, China

3 School of Geodesy & Geomatics Engineering, Huaihai Institute of Technology, Lianyungang, Jiangsu Province, China

References

- [1] Bird, E., 2008. *Coastal Geomorphology: An Introduction*, 2nd Ed., ISBN-9780470517291, Wiley, New York, pp. 436.
- [2] Chen, W., Zhang, H., Zhang, F., 1991. Chronological study on neo-tectonic movement in the Zhujiang (Pearl River) Delta area, *Seismology and Geology*, 13(2), 213–219.
- [3] Chen, W., 1998. Quaternary geology and seismic risk assessment in the Pearl River Delta and its vicinity area, *South China Journal of Seismology*, 18(2), 58–62.
- [4] Chen, W., Zhao, H., Chang, Y., Lu, B., 2001. The rate of late Quaternary vertical motion of the Zhujiang (Pearl River) Delta, *Seismology and Geology*, 23(4), 527–536.
- [5] Chen, G., Zhang, K., Chen, F., 1994. Sedimentary paleo-geography of late Pleistocene in the Pearl River Delta, *Quaternary Research*, 1, 67–74 (in Chinese).
- [6] Chen, G., Zhang, K., Chen, H., He, X., 1995. Research on latest reactivity of faults in the Pearl River Delta, *South China Journal of Seismology*, 15(3), 16–21 (in Chinese).

- [7] Chen, G., Zhang, K., Li, L., 2002. Development of the Pearl River Delta in SE China and its relations to reactivation of basement faults, *Journal of Geosciences of China*, 14(1), 17–24 (in Chinese).
- [8] Dong, H., Huang, C., Zeng, M., Chen, W., 2012. Feature and formation mechanism of the Quaternary fault plane at Xilingang, Foshan City, *Seismology and Geology*, 34(2), 313–324 (in Chinese).
- [9] Driese, S.G., Li, Z.H., Horn, S.P., 2005. Late Pleistocene and Holocene climate and geomorphic histories as interpreted from a 23,000 ^{14}C yr B.P. paleosol and floodplain soils, southeastern West Virginia, USA, *Quaternary Research*, 63(2), 136–149.
- [10] Gao, F., 2006. Environmental evolution of the Pearl River Delta in Late Quaternary, Master Thesis, Zhongshan University, pp. 91.
- [11] Huang, Z., Zong, Y., 1982. Grain size parameters and sedimentary facies of the Quaternary sequences in the Pearl River Delta, China, *Tropical Geography*, 2, 82–90 (in Chinese).
- [12] Huang, Y., Xia, F., Chen, G., 1983. The fault controlling function in the formation of the Pearl River Delta, *Journal of Oceanography*, 5(3), 316–327 (in Chinese).
- [13] Huang, Z., Li, P., Zhang, Z., Li, K., 1985. Characteristics of the Quaternary deposits in the Pearl River Delta, *Geological Review*, 31(2), 159–164 (in Chinese).
- [14] Huang, Z., Li, P., Zhang, Z., Zong, Y., 1986. Sea-level change since the Late Pleistocene along the south coast of China. In: Qin, Y., Zhao, S. (Eds.), *China Sea Level Changes*. China Ocean Press, Beijing, pp. 178–194 (in Chinese).
- [15] Huang, Z., Li, P., Zhang, Z., Li, K., 1987. The geomorphological evolution of the Pearl River Delta. In: Gardiner, V. (Ed.), *International Geomorphology 1986 Part I*. Wiley & Sons Ltd, New York, pp. 989–997.
- [16] Li, P., Huang, Z., Zhang, Z., Li, K., 1984. The Quaternary strata of the Pearl River Delta, *Geographic Sciences*, 2, 1–6 (in Chinese).
- [17] Li, P., Qiao, P., Zheng, H., Fang, G., Huang, G., 1990. *The Environmental Evolution of the Pearl River Delta in the Last 10,000 Years* (in Chinese). China Ocean Press, Beijing, pp. 154.
- [18] Long, Y., Huo, C., 1990. Sedimentary characteristics of late Quaternary in the Pearl River Delta, *Marine Sciences*, 4, 7–13 (in Chinese).
- [19] Ma, D., Xu, M., Zhou, Q., Zhang, G., Lan, X., 1988. Sedimentary facies sequences of the Pearl River Delta, *Marine Geology & Quaternary Geology*, 8(1), 43–53.
- [20] Marghany, M., Sabu, Z., Hashim, M., 2010. Mapping coastal geomorphology changes using synthetic aperture radar data, *International Journal of Physical Science*, 5(12), 1890–1896.

- [21] Pedoja, K., Shen, J. W., Kershaw, S. et al., 2008. Coastal Quaternary morphologies on the northern coast of the South China Sea, China, and their implications for current tectonic models: a review and preliminary study, *Marine Geology*, 255, 103–117.
- [22] Siddall, M., Rohling, E.J., Thompson, W.G., Waelbroeck, C., 2008. Marine Isotope stage 3 sea level fluctuations: data synthesis and new outlook, *Reviews of Geophysics*, 46, RG4003, 1–29.
- [23] Smith, L.C., 2002. Emerging applications of interferometric synthetic aperture radar (InSAR) in geomorphology and hydrology, *Annals of the Association of American Geographers*, 92(3), 385–398.
- [24] Song, F., Wang, Y., Li, C., Chen, W., Huang, R., Zhao, H., 2003. Late Quaternary vertical dislocation rate on several faults in the Pearl River Delta area, *Seismology and Geology*, 25 (2), 203–210.
- [25] Stuiver, M., Reimer, P.J., Braziunas, T.F., 1998. High-precision radiocarbon age calibration for terrestrial and marine samples, *Radiocarbon*, 40, 1127–1151.
- [26] Wang, J., Cao, L., Wang, X., Yang, X., Yang, J., Su, Z., 2009. Evolution of sedimentary facies and paleo-environment during the late Quaternary in Wanqingsha area of the Pearl River Delta, *Marine Geology & Quaternary Geology*, 29(6), 35–41.
- [27] Xu, N., Jiang, Y., Jia, J., Wang, J., Liu, H., 2005. Crustal stable zones and its characteristics in the Pearl River Delta, *Geological Hazards & Environmental Protection*, 16, 395–399.
- [28] Yim, W.W.-S., 1999. Radiocarbon dating and the reconstruction of late Quaternary sea-level changes, *Quaternary International*, 55, 77–91.
- [29] Zhang, H., 1980. Fault-block delta, *Journal of Geography*, 1, 18–30 (in Chinese).
- [30] Zhang, H., 1983. Fault function in the formation and development of the Pearl River Delta, *Journal of Oceanography*, 2, 202–221 (in Chinese).
- [31] Zhang, K., Chen, G., Zhuang, W., Peng, Z., Hou, W. 2009. New evidences for late Quaternary tectonic movement in the northern Pearl River Delta, *South China Journal of Seismology*, 29, 22–26 (in Chinese).
- [32] Zhang, X., 2009. Studies of Guangzhou-Conghua fault zone and its activities, Master Thesis, Zhongshan University, pp. 86.
- [33] Zhong, J., Zhan, W., 1996. Analysis for neo-tectonic movement and its crustal stability in the Pearl River Delta, *South China Journal of Seismology*, 16, 57–63 (in Chinese).
- [34] Zong, Y., Lloyd, J.M., Leng, M.J., Yim, W.W.-S., Huang, G., 2006. Reconstruction of Holocene monsoon history from the Pearl River estuary, southern China, using diatoms and carbon isotope ratios, *The Holocene*, 16, 1–13.

- [36] Zong, Y., Huang, G., Switzer, A.D., Yu, F., Yim, W.W.-S., 2009. An evolutionary model for the Holocene formation of the Pearl River delta, China, *The Holocene*, 19, 129–142.

IntechOpen

IntechOpen

