

Study On The Characteristics And Types Of Rock Geomorphology In Shandong Province

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Abstract :

Due to its unique natural geographical environment , Shandong Province has formed a variety of rocky landscapes . The types of rocky landforms distributed in Shandong Province mainly include volcanic landforms , karst landforms , Daigu landforms , clastic rock landforms , estuary landforms and coastal landforms . This paper will describe the types, distribution and causes of rocky landforms in Shandong in order to achieve the purpose of summarizing the types of rocky landforms.

Key words : rock landform; geological environment; Shandong Province

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I. Introduction

Rock geomorphology is an important part of structural geomorphology [1,2]. The formation of rock landforms is mainly affected by the nature of the rock itself and the natural geographical environment. The geomorphological characteristics of areas with strong crustal uplift or subsidence are very prominent; rock geomorphology will also be affected by external forces such as physical weathering, mechanical transportation, deposition, physical and chemical transportation; the surrounding climate environment, including temperature Factors such as moisture, humidity and rainfall also have a significant shaping effect on the formation of rocky landforms. At the same time, landform types also restrict the changes of natural environment elements at different scales, thus causing the differentiation of natural environments[3,4].

In my country, the most common rock landforms are karst landform, Danxia landform, quartz sandstone landform, wind-eroded sandstone landform, granite landform, basalt landform and Daigu landform. The formation of these rock landforms is closely related to the type and characteristics of rocks, and is also affected by tectonic movements, and is related to the climate, weathering and erosion ability and strength of the rocks.

Shandong Province is located in the eastern coastal area of my country. The terrain is dominated by mountains and hills. It is located in the temperate monsoon climate zone. The rain and heat are in the same period, and there are many torrential rains in summer. The characteristics of the monsoon climate also create conditions for the formation of various landform types. Shandong is located at the junction of the North China Plate and the South China Plate. In the central part of Shandong Province, there is the Tanlu Fault Zone that runs through the north and the south. In the coastal area, there is the Wulian-Yantai Fault Zone. The geological tectonic movement in Shandong Province is active. Shandong has a coastline of 3,290km, and the action of the ocean has also had a dramatic impact on the formation of rocky landforms, forming a unique coastal island landform. In addition, volcanic landforms, karst landforms and Daigu landforms are distributed in Shandong.

II. Geological and landform overview of Shandong Province

Geological conditions are the foundation of the natural environment and natural resources. The rock characteristics and combination of strata in different geological periods in Shandong Province, as well as the basic pattern and activity nature of regional geological structures control the type, distribution and basic characteristics of Shandong's landforms, and also affect the hydrology, soil, vegetation and other elements in the geographical environment. Have a big impact. The strata of Shandong Province can be divided into North China Plain , West Shandong and East Shandong. The strata in Shandong Province are very old, ranging from Mesoarchean to Quaternary strata. In terms of tectonics, Shandong is an integral part of the North China fault block. The uplifted part of the fault block is the Central South Shandong and Eastern Shandong Peninsula, which is called the "Shandong Platform Anticline". Northwest Shandong and Southwest Shandong belong to the depressed part of the North China fault block. Due to the long-term sag in the geological history, the sedimentary layer continued to expand eastward, and the Mesozoic Jurassic return uplifted the Central and Southern Shandong Mountains and Shandong The eastern peninsula is connected with the mainland . The regional structures in Shandong are dominated by fault structures, with less developed fold structures. Among them, the north-north -east and northeast-trending Yishu and Liaokao fault zones , and the nearly east-west-trending Qiguang fault zone are the most important. They constitute the main faults and important geological boundaries of the Shandong fault pattern.

Shandong Province is located on the third step of China's third-level terrain ladder. Most of the altitude is 500m below, and the relative height is mostly between 200m and 350m. The terrain does not fluctuate much, and the slope is basically below 20°. Shandong's inland landform types can be mainly divided into seven basic landform types: Zhongshan, low mountains, hills, basins, piedmont (inter) plains, alluvial plains, and the Yellow River Delta. 37.45 % , plains accounted for 62.55 % . The highest peak in the province is Mount Tai, with an altitude of 1532m; the Yellow River Delta has an altitude of 2m~ 10m, which is the lowest point in the province. Along the long and tortuous coastline, rich and diverse coastal landforms have developed. According to the regional differentiation characteristics of geomorphic types in Shandong Province, Shandong Province can be divided into three geomorphic regions: the hilly region in central and southern Shandong, the low mountainous and hilly region in eastern Shandong, and the plain region in western Shandong and northern Shandong .

III. Main landform types in Shandong Province

Volcanic landform types

Volcanic landform is one of the main types of tectonic landform, and the classification criteria of volcanic landform types are nothing more than shape, origin and material composition. The landform formed when underground magma erupts from a volcanic vent and condenses on the surface is called volcanic landform; the landform formed by molten magma flowing along the surface and cooling is called lava landform [5].

Penglai Yingkou Mountain volcanic landform

The area around Penglai, Yantai is an area where Cenozoic volcanoes developed[6,7]. Yingkou Mountain Volcano is an ancient volcano in the area, located in Beigou Town, Penglai City, Shandong Province. Yingkoushan Volcano is located at the junction of the hilly landform area and the faulted plain of Huangxian County. On the whole, the shape of Yingkou Mountain presents an oval shape, and the surrounding terrain is a platform plain. The central part of the volcanic cone is depressed and is a crater depression with a relatively flat bottom. The crater diameter can reach about 40m, the altitude is 170-180m, and the crater depth is about 50m. The crater is not closed, but is cut open by an east-west ravine in the west, forming a horseshoe-shaped crater. In addition to this one incision, there are five larger incisions around the mountain. There are many strata exposed around Yingkou Mountain. There are thicker basalt strata in the southern part of the mountain ; in Beilinyuan Village on

the north side of Yingkou Mountain, gneiss and schist from the metamorphic rock base of the Jiaodong Group are distributed; the entire mountain of Yingkou Mountain is composed of volcaniclastic rocks and volcanic ash composition.

Lava landforms

(1) Lava Terrace

Lava platforms are mainly distributed in the north of the Penglai West Mountain-Crouching Mountain line, near Zhuyou-Yanglan in Huangxian County, and in the Wutu and Yidu Zhengmu areas from Linqu Liushan to Changle. The Penglai lava platform is composed of dense massive basalt and brick-red-dark gray porous slag-like basalt. Terraces are generally 30 to 60 meters above sea level, and are mostly composed of small forms such as slow hills and gullies. The lava basement is the denuded surface of the gneiss and schist of the Jiaodong Group in the Proterozoic. The Beigou-Zhuyou lava platform in the western part of Penglai and the eastern edge of Huangxian County is located in the downthrown plate on the west side of the Linglong-Beigou fault. The platform is 30 to 100 meters above sea level, the ground is open and flat, sloping to the north and west, and the basalt layer gradually hides underground in the Huangxian Plain. There are several layers of alluvial and diluvial gray-yellow sandy soil between the basalt layers, 3 to 10 meters thick. Underlying the bottom of the basalt is a Mesocene - Pliocene fluvial gravel layer.

(2) Lava Fangshan

The all-lava Fangshan Mountains in Shandong Province are distributed in Weicheng District in the north of the Yishu fault zone, and in the Linqu-Changle volcanic activity area. Such as Fushan in Weicheng District, Fangshan, Cheluoding and Dagushan in Changle, Zhongjiahangshan, Anshantou and Niushan in Linqu. All of them are composed of residual rock masses destroyed by later erosion of basalt platforms. The scale is small, the altitude is between 300 and 350 meters, and the area of the mountaintop is generally not more than 1 square kilometer.

Fangshan is covered with lava and has a dual structure. The top is covered by a thick basaltic lava layer with a nearly horizontal occurrence. The base is Archaean or Proterozoic crystalline metamorphic rocks. Paleoweathering crust or fluvial sand and gravel layers often exist between the two. Its distribution is Bianshan, Lishan and Longshan in Yishui, Tangwangshan, Daanshan and Liushan in Anqiu, Rongshanzi and Changshanzi in the south of Changle, Taipingding at the junction of Yishui, Linqu and Anqiu, Dafangshan in Qixia, Tangshan Peng, Xiaofangshan. Dafang Mountain in Qixia is the largest, with a top area of about 4 square kilometers. It is the largest lava mountain in Shandong. The top of the mountain is slightly higher in the north and slightly lower in the south, with an altitude between 340 and 360 meters. The highest point is a lonely hill with an altitude of 404 meters. The Dafangshan basalt caprock is 30-40 meters thick, and the underlying Jiaodong Group metamorphic rocks are sandwiched with thin gray-white gravel layers and red weathering crusts.

(3) Lava hills

Lava mounds are low hills or ridges formed by lava accumulations after long-term erosion and damage. They are mostly distributed on the edge of lava terraces or on the terraces, with various forms. There are round gentle hills, elongated ridges or irregular low hills, which are commonly called "ports" in the Changle area. Such as Dabu, Renjiabu, etc. Generally, the relative height is tens of meters, and the slope is between 10 ° and 20 °. Its composition is mostly slag-like or porous layered basalt, and lava mounds with dense massive or columnar joints are rare. It is also distributed in Penglai.

(4) Volcanic cone

Late Cenozoic volcanic cone landforms composed of lava or volcanic debris are mainly distributed in the Linqi-Changle and Penglai regions, especially Linqi and Changle are the most preserved, with more than 30 volcanic cones. Specifically, it can be divided into: caldera cone, composite volcanic cone, lava cone and parasitic volcanic cone. Caldera cone means that the crater on the volcanic cone has been destroyed, the outer mountain body is incomplete, the plane outline is like a horseshoe, and the shape of the mountain body is truncated conical. There are many volcanic mounds in Zhoupo. Volcanoes belonging to this type are beneficial to Zhengmuxiang Mountain, Qiaoguanbao Mountain in Changle, Liushan Mountain in Linqi, Yingkou Mountain and Dawang Mountain in Beigou of Penglai; composite volcanic cones are nearly conical volcanoes formed by the accumulation of lava and volcanic debris. It is formed by the alternation of central eruption and lava overflow. The plane outline is nearly round or oval, and the shape is a layered cone. The size of the mountain varies, but there are few obvious craters on the top. There are also large differences in the era of formation. Formers of the Middle Miocene are all distributed in Changle and Linqi, such as Qushan, Qingnianshan and Yaoshan in Linqi. Formers of the Pliocene, such as Xishan, Chishan, and Hongshishan in Penglai. The Quaternary was formed only by the mountains in Wudi in the northern Lubei Plain; lava cones are conical mountains formed by the accumulation of lava overflowing from the center. Concentrated in the Linqi-Changle volcanic activity area, there are nearly 30 of them in size. It is a product of late Miocene volcanic activity. The volcanic cone is composed of dense massive basalt, and the lava in the center of the mountain has extremely well-developed prismatic joints and various occurrences. Most of the mountains have no craters, the plane outline is nearly round and oval, and the shape is like a bell, a gentle hill and a flat-topped cone.

Karst landform

Under the modern conditions dominated by flowing water erosion and denudation, the overall landform landscape in the Shandong karst area is a temperate zone dissolution-erosion or denudation type, and the landform combination types mainly include: (1) dissolution-erosion and denudation low mountains and hills, and other Positive terrain refers to soluble rock mountains with an altitude of 100 meters to nearly 1,000 meters. These mountains do not reflect the typical karst mountain form in southern karst areas, but often show obvious structural features, such as Fangshan and single-sided mountains; negative terrain Mainly erosion valleys and wadi. (2) Dissolution-erosion and denudation intermountain valley plains, which are formed on the basis of fault-block depressions, and are distributed alternately with fault-block uplifts and mountains. The terrain is flat and wide, and some large rivers run through it. (3) Dissolution-denudation piedmont residual hill plains are widely distributed in the piedmont area, with gentle and slight inclines, the bedrock is buried very shallow or exposed, and limestone residual hills are scattered on it. The karst landforms in Shandong show obvious regional differences. In the same climatic zone with little difference in hydrothermal conditions, this difference is mainly caused by geological factors, among which the characteristics of the Cenozoic tectonic movement and the corresponding structural pattern, as well as the distribution of rock layers under the control play a leading role. , thickness and exposure.

Tai-Shandong-Yishan area in the northern part of Central and South Shandong Mountains

The intensity of Cenozoic tectonic activity was relatively high, and it was the central area of fault block uplift, forming three fault block uplift mountains, Taishan, Lushan, and Yishan, with an altitude of more than 1,000 meters. The main peak area has exposed the Taishan Group metamorphic rock basement and soluble rock The strata are mainly distributed in a large area from the north side of the main peak area to the edge of the mountain, forming dissolution-erosion low mountains and hills. The landform shows the characteristics of prime age and strong water erosion, with high mountains and deep ravines. For example, the depth of ravine cutting in

the Lushan area reaches 150~500m, and the ravine cutting density is 1.14km/km². The rivers that cross the mountains from south to north all show typical wadi characteristics. The mountains in the Fenshuiling area often form a narrow and steep top surface in the form of long wall, on which there are partially recognizable ancient denudation surfaces, karst depressions and karst buckets. The aforementioned ancient karst depressions are all in the watershed zone of the Zihe River Basin in Lushan. Because the Cambrian and Ordovician strata in this area are fully exposed, wide in area, and thick, there are also many karst caves developed and preserved, such as the above-mentioned karst cave group in the Tumen area of Yiyuan County. A series of spring groups are formed in the northern piedmont, such as Jinan Spring Group, Mingshui Spring Group, Zibo Spring Group and Linqu Laolongwan Spring Group.

Yishui-Mengyin, Sishui-Pingyi-Feixian, and northern Zaozhuang in the central and southern mountainous areas of Shandong

The structural pattern is a series of NW -SE trending fault block mountains and depression valleys alternately distributed. The uplifting history of the mountains is relatively early (Early Tertiary), and it has been denuded for a long time. Therefore, most of the sedimentary strata in the mountains have been peeled off, and the Cambrian and Ordovician strata are only distributed in narrow strips on the flanks of the mountains. Formation of dissolution - eroded or denuded hills. Most of the mountains have an obvious single-sided mountain shape. In many areas, only the Lower and Middle Cambrian strata remain, and the middle and lower parts of the mountain are Lower Cambrian shale and thin marl, and the thick Middle Cambrian Zhangxia Formation limestone is on the top of the mountain, forming a typical square. The mountain shape is locally called "Gu". Parallel to the mountains, there are a series of long strips of wide erosion-denudation intermountain valley plains, such as Xintai-Mengyin Plain, Sishui-Pingyi-Feixian Plain, Zaozhuang-Taocun Plain, etc. Due to the wide flat ground in these areas, shallow soil coverage, and shallow water conditions are better, semi-buried or exposed stone buds are better developed and widely distributed than those in central, southern and northern Shandong, and large areas of stone buds are common.

The edge of central and southern Shandong mountains

Around Dongping Lake in the west and southwest of the region, Liangshan, Jiaxiang, Xuecheng, and Zaozhuang Yicheng and Cangshan in the south and southeast of the region, the landforms present the characteristics of old age, which is considered to be the lowest point formed by long-term denudation in central and southern Shandong. The denudation surface of the first level—the denudation surface of the Lincheng period, from the karst point of view, is a plain of erosion-denudation piedmont. The ground in these places is flat, the bedrock is buried shallowly, and the relative height is about 100 meters. The round and low limestone residual hills are scattered scattered, and some long karst caves are also developed on the residual hills, such as the Phoenix Cave (length >100m) in Liangshan, Jiaxiang The Green Mountain Cave (120m).

North of Jiaodong Peninsula

The Penglai and Yantai areas are located in the Jiaobei uplift belt of the eastern Shandong uplift area. They have experienced long-term denudation since the end of the Proterozoic period, extensively exposing the basement of Archaean-Lower Proterozoic metamorphic rocks. The soluble rocks are mainly marble, which belongs to the dissolution- Denuded hill type. The marble mountains are in the shape of low hills and peaks with a relative height of about 100 meters. The mountains are mostly separated from each other, and the valleys in between are very wide. There are also some larger caves in marble, such as Fengjiazhuang Cave in Yantai (240m) and Kangshan Cave (152m) in Daji's hometown in Penglai. In addition, there are more than 50 kilometers of

coastal zones composed of marble along the coasts of Yantai and Penglai, forming a sea erosion-dissolution karst coastal landscape. This section of the coast is dominated by bedrock eroded shores, with marble sea cliffs, sea erosion platforms, sea erosion-dissolution caves, marble gravel beaches, marble reef buds, and bio-dissolution related to marine organisms on coastal reefs. Nest shape.

Daigu landform

Overview of Daigu landform

Daigu landforms are concentrated in Daigu Town, Mengyin County. The geographic location is $118^{\circ}04'26.0''\sim 118^{\circ}10'37.9''$ east longitude $35^{\circ}54'48.4''\sim 35^{\circ}57'03.1''$ north latitude. It reaches Lu Gu in the north, Wolong Gu in the east, Ban Gu in the south, and Mulin Gu in the west. Daigu landform is the fifth landform type after Zhangjiajie landform, Zhangjiajie landform, Danxia landform, and karst landform. Therefore, the study of this landform has become a hot issue. Because Daigu landform is one of the typical climate landforms, it is determined by climate factors and lithological factors. The Daigu landform can only develop in China's temperate and boreal regions due to its lithological characteristics. If it is in tropical and subtropical regions, it has already been completely karstized and has become a karst landform, a type of climate landform, and it is by no means the appearance of today's rock landforms. Therefore, China's rock landforms currently only include four types: Zhangshiya landform (quartz sandstone), Zhangjiajie landform (quartz sandstone), Danxia landform (sandy conglomerate) and Daigu landform (limestone).

Main development areas of Daigu landform in Shandong Province

There are four concentrated Daigu areas in Shandong and other scattered individual Gu areas:

(1) As mentioned above, Daigu Town in Mengyin is the most numerous, with typical and diverse shapes, and developed in the Cambrian Zhangxia Formation limestone and Mantou Formation shale.

(2) Zhangxia Town, Changqing District, is a standard section with limestone as the main body of the Cambrian Zhangxia Formation in the Proterozoic, such as Gushan, Mantoushan and Zhujiaping in Zhangxia (also one of Fangshan).

(3) In the Daigu Group of Pingyi, the lower part of the Zengzishan body is the Neoproterozoic Yishan sequence gneissic porphyritic granodiorite. Due to the imperviousness of the lower granite, the bottom of the upper limestone layer is obviously eroded, forming karst caves, so that the Gu shape is affected, and the Gu shape is not typical, such as Transparent Gu, Yinhe Mountain, Optimus Prime, etc.

Clastic landforms

The clastic rock landforms in Shandong are mainly red sandstone landforms deposited in Mesozoic fluvial and lacustrine facies, which belong to red bed landforms. Due to the gentle undulation of the terrain, most of them are red-bed remnant (slow) hills and red-bed canyons. Some mountains are relatively high and have the characteristics of Danxia landforms. Professor Huang Jin, director of the Department of Geography of the University, inspected the Jishan Provincial Geopark in Linshu County, Linyi City, Shandong Province in 2011, and identified the Daijian red sandstone landform as the 852nd Danxia landform in my country and the first Danxia landform in Shandong Province. landforms.

Qishan Danxia landform landscape

The strata are red fluvial and lacustrine conglomerates of the Cretaceous Dasheng Group and Wang Group, which are characterized by rich fossils such as dinosaur footprints. They are distributed in the Keshan Provincial Geopark in Linshu County, Linyi City. Affected by the tectonic activity of the Yimu Fault, the

neotectonic movement in this area is very active, the terrain is undulating, and the rock layer folds are developed. Under the influence of flowing water, weathering, gravity and other factors, red bed landforms such as steamed bun-shaped hills and residual hills are formed, and the structure In areas with strong activity, the rock formations are tilted or folded, forming landforms such as red bed canyons and monocline mountains.

Malingshan red bed monoclinic landform landscape

Distributed in Malingshan Provincial Geological Park, Tancheng County, Linyi City, it occurs in the clastic sedimentary rock strata of the Dasheng Group in the Cretaceous period. clear. Because it is located in the Yishu fault zone, the tectonic movement in this area is strong, and the sedimentary rock layers are inclined, bent or even reversed. Cross-bedding and folds can be seen everywhere, and the scale is large, forming a spectacular red-bed monocline landform, with layers of rock layers inclined and superimposed. The unique landscape is called "thousand layer rock". Due to the different hardness and differential weathering of sandstone and conglomerate, the rock surface is concave and convex, and the rock layers are patchwork, red and white.

The landform and landscape of Jingangkou Red Layer Canyon

Distributed in the Laiyang Cretaceous Dinosaur National Geological Park, there are more than 10 deep-cut "V"-shaped valleys or "U"-shaped valleys, which are the result of the joint action of tectonic activities and water erosion. On both sides of the valley are purple-red sandstone and gray-white conglomerate interbedded in the Wangshiya Hongtuya Formation. The red-bed canyon is winding, with a width of 30-150m, and the longest reaches 17km. Geological phenomena such as small geological structures on the bottom of the valley and on both sides are developed, and it is rich in dinosaur fossils, so it is also called "Dinosaur Valley". From June 3 to 5, 2010, more than 20 experts and scholars from the China Institute of Geological and Environmental Monitoring, the University of Kansas, and the China Geological Museum investigated the landform type, and agreed that the red bed canyon landform in the park is very aesthetic. Value, rare at home and abroad.

Sishan red layer canyon landform landscape

Distributed in Xintaisishan Provincial Geological Park, developed in the red sandstone layer of the Santai Formation of the Zibo Group, the lithological combination is gray-red, purple-red sandstone and conglomerate interbedded, mainly gravel and sandy braided fluvial deposits , partially interspersed with alluvial fan facies deposits. The sandstone is thick, with clear bedding, and the valleys develop along the direction of flowing water erosion. It is the result of the joint action of tectonic activities and flowing water erosion. The scale is small but very ornamental. It is also an excellent place to study the red clastic depositional environment of the Santai Formation of the Zibo Group. place.

Estuarine landforms

The most typical estuary landform in Shandong Province is the Yellow River delta landform . The sediment carried by the Yellow River is deposited at the mouth of the river due to the support and flocculation of sea water . The channel where the Yellow River enters the sea has many forks, and the position of the mouth of the Yellow River fluctuates. Therefore, a huge Yellow River delta sedimentary plain landform is formed at the mouth of the sea.

The Yellow River Delta is actually a cumulative landform composed of dozens of distributary reaches and small delta lobes at different times. According to the history of delta development and modern sedimentary characteristics, the delta landform can be divided into three landform zones, namely: the upper delta alluvial plain, the delta alluvial-marine plain, and the tidal flat around the delta.

Delta alluvial plain

The alluvial plain in the upper part of the Yellow River Delta formed since 1855 AD has an elevation of 6-7m at its apex, and drops to 2.5-3m towards the sea, which roughly corresponds to the super high tide line in the region. The upper alluvial plain consists of fluvial highlands and river flood plains. River highlands have two forms, finger-shaped hills and palm-shaped highlands. Among them, the finger-shaped hills can be divided into three types: distributary channels in various stages (river bed, central beach and side beach), natural embankments and breach fans (river channels and fan-shaped bodies). River flood plains are mainly depressions, including inter-river depressions and inter-mountain depressions. Micro-landforms such as saline-alkali flats, wet depressions or trenches, lakes and swamps can all appear.

Dozens of large and small distributary channels in each phase of the delta are aboveground channels. The river bed and the deposits on both sides (natural embankment, crevasse fan) are 1~2m above the surrounding ground, diverging from the delta apex to the sea fingers. There are inter-river depressions between the distributary channels, and the areas where the channels are relatively densely superimposed form relatively wide finger-shaped hillocks. The uplands converge toward the Ninghai-Yuwa apex of the delta to form a palm-shaped highland with an elevation of 6-7m.

Delta alluvial-marine plain

From below the shoreline of the delta sedimentary plain to the regional average high tide line, there is a wide and flat land ring in the state of wetland—the alluvial marine plain or supertidal flat in the lower part of the delta. In most parts of this area, the average slope to the sea is less than 1/10000. The width of the ancient delta area in the west is 20-30 km, and the width of the modern delta area is 10-20 km. The modern delta supertidal flat is divided into two parts: the current water lobe and the abandoned flow path lobe. The former consists of distributary channels, estuary spits and coastal wetlands, while the latter consists of abandoned distributary channels and their residual alluvial islands, coastal wetlands, branched tidal ditches and rudimentary shell beaches. The ancient delta supertidal flat is divided into two parts: the current water lobe and the abandoned flow path lobe. The former consists of distributary channels, estuary spits and coastal wetlands, while the latter consists of abandoned distributary channels and their residual alluvial islands, coastal wetlands, branched tidal ditches and rudimentary shell beaches. The ancient delta supertidal flat is divided into three parts: the upper zone, the mean high tide line of spring tides, and the lower zone. The upper zone includes types such as saline-alkali flats, residual alluvial islands, and branching tidal ditches. The lower zone includes types such as saline wet depressions, tidal ditches, and shell banks.

Tidal flats around the delta

The super tidal flat landform is silty intertidal shoal from below the coastline to the land area around the spring tide and low tide line. Except for the current Shuihe Estuary and the vicinity of the original Shenxiangou, most of the shoals have obvious zoning of landforms: one is the tidal flats of ancient and modern abandoned leaves, which can be divided into scour tidal flats and silting tidal flats two kinds. The former can be divided into the inferior beach in the upper zone, the pit beach in the middle zone and the corrugated beach in the lower zone; Ripple Beach. The second is the intertidal zone of the current water estuary—the flower-shaped estuary formed by the downward branching runoff channel and its side beaches. There are two types of scour and silt in the middle and upper tidal flats. According to statistics, scour-type tidal flats account for more than 58% of the total tidal flat shoreline, and the upper part has a 5-20cm high first-order or several-order scour bank, and there are shell beaches on the ridge. The scour-type tidal flat belt in the ancient delta reaches the outer edge of the shell embankment

island, forming scour ridges of tens of centimeters and a maximum height of 1~2m. There are mud and gravel at the bottom of the ridge, and outwards is an upper belt inferior beach with a width of 100 to 100 meters. The scour pits in the middle zone are dish-shaped, 5-30cm deep, and 1-10cm wide and long. The silting type tidal flats are mainly distributed in the surrounding bay-shaped banks, and both sides of the sand spit of the current water estuary. The secant line is basically consistent with the regional average high tide line. Above this (super tidal flat), the beach becomes thinner. All muddy fine silt or clayey silt are spread flat on the silted tidal flat. The tidal flat is interbedded with coarse and fine silt, and the beach surface is covered with ridges in the same direction as the ebb tide, with a relative undulation of 5-15cm, a width of 1-3m, and a length of 3-10m. The entire beach surface has a scale-like landform. In the subtidal zone, the pits or ridges disappear, and the beach surface is rough and solid, mostly composed of coarse silt or sandy silt, with continuous ripples until the low tide line. The tidal flats of the Yellow River Delta, except for the protruding part at the northeast corner, are all sedimentary zones, accounting for 2/5~1/2 of the width of the entire tidal flat. Several large tidal gullies developed in the northern part of the delta, and their main gullies can run through the upper, middle and lower zones of the entire tidal flat. In the intertidal zone outside the mouth of the current water channel, there is a flower-shaped protruding estuary beach formed by the runoff channel and its side beach that diverge downward, without the above-mentioned landform zonation of the tidal flat. It is a shoal mainly formed by river action, and it is an intertidal zone of an estuary shoal in the sense of ebb and flow, and does not have the geomorphic properties of a tidal shoal.

Coastal landforms

The coastline of Shandong Province is very favorable. The coastline is long and tortuous. From Dahekou in Wudi County to Xiuzhen Riverkou in Rizhao County, the total length is 3290km, accounting for one-sixth of the total length of the country's coastline. Due to the different natural and geographical conditions of different sections of the coast, the types of coastal landforms in Shandong Province are also complex and diverse. The coasts of Shandong Province can be roughly divided into mountainous harbor coasts and plain muddy coasts according to their morphological classification.

Mountain coast

Shandong's mountain coast begins at the mouth of the Xiuzhen River and ends at Hutou Cliff in the north. This type of coast has been continuously developed on the basis of the Jiaoliao uplift belt and under the influence of the terrain conditions of the Shandong hills and the southern Shandong mountains, forming its current form. Because the mountainous coastline is very tortuous, it is convenient for the construction of harbors, so there are many good harbors. The nearshore water level is relatively deep, the main coastal dynamics are waves, and the coastal sediments are mostly coarse-grained sediments. The rulers and ministers of the rivers entering the sea show the characteristics of shortness. This type of coast can also be subdivided into three subtypes: headland coast, sand bank lagoon coast and coastal small plain.

Plain coast

The formation of the plain coast is related to the action of rivers and tides. The plain coast is mainly distributed in the Laizhou Bay and the Yellow River Delta .

(1) Laizhou Bay silty muddy coast

Laizhou Bay is located at the junction of the Jiaoliao uplift belt and North China subsidence. The Tanlu fault zone crosses Laizhou Bay obliquely with the shoreline. The sediment layer is thinner in the east of the Weihe River, but thicker in the west of the Weihe River. This is closely related to the neotectonic movement in this area. At the same time, the Xiaoqing River, Wei River, Bailang River and Jiaolai River flow into Laizhou Bay, and the

sediment carried by the rivers and tides gradually forms a flat and wide silt and muddy coast. The position of the coastline will be affected by natural environmental factors, therefore, the coast of Laizhou Bay gradually silts towards the sea at a rate of several meters per year. There is a brine layer of 50-60 meters underground in Laizhou Bay, which provides conditions for the development of sea salt resources in Laizhou Bay.

(2) Along the Yellow River Delta

The Yellow River is world-famous for its large sand content. In addition to being deposited along the coast, more sediment carried from the upstream was deposited at the estuary, gradually forming the current Yellow River Delta landform. The tributaries of the Yellow River are numerous and fluctuate all the year round, forming a large area of fan-shaped deposits. The terrain is very flat, and the landform and sediment distribution are extremely complex. The material deposited in the Yellow River Delta has a finer particle size in the upper part and also contains a small amount of coarse particles; the silt deposits in the estuary are composed of silt materials.

IV. Conclusion

Rock landform types have diverse characteristics. Shandong Province is located in a temperate monsoon climate zone, where flowing water and temperature play an important role in shaping rocky landforms; the Tanlu fault zone runs through the north and south, and the entire Shandong is at the junction of the North China Plate and the South China Plate, with strong geological activities; Shandong Province has various terrain types, Hills, mountains and coastal plains are all distributed, and different terrain conditions also affect the development and development of rocky landforms.

The types of rocky landforms in Shandong Province are diverse , which provides a research site for research in the fields of geography and geology . At the same time, a variety of landforms are distributed in various parts of Shandong. Based on different rocky landscapes, the geotourism industry can be developed, and the goal of popularizing geological knowledge can be achieved while promoting local economic development.

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