中国海岸带地质环境与资源

Geo-Environment and Resources in Coastal area of China

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Abstract: The geology, geomorphology, geo-environment and natural scenery and their classifications along coastal area of China are briefly described in this paper. Furthermore, the abundant resources development and utilization of geology and environment, including mineral resources, building materials, geological spaces, geological engineering of harbors and geological tourist attractions etc. are also presented herein. The formation of main strait, gulf, port and their urban development are discussed as well in this paper.

Key words: geo-environment; resources of geology; geological engineering; urban development

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1 BRIEF SURVEY OF CHINA EXTENDED COAST

China lies to the east of Asia continent on the east of the Pacific. The Bohai Sea, Yellow Sea, East Sea and South Sea are distributed from north to south along eastern border. (see Fig.1) China coastline is more than 18000 km that is from Yalu River mouth, Liaodong peninsula, Shandong peninsula, Shanghai, Zhejiang, Fujian, then turning to westward at Shantou of Guangdong and Guangxi provinces to river mouth of Beican.

Fig.1 Location of China coastal area

Coastline is the intersection of continent and sea as well as the mutual influence zone of lithosphere, atmosphere, hydrosphere and biosphere. China continental coast straddles across 3 climate zones of tropical, subtropical and temperate. The temperate zone takes about 60%.

The topography is higher in the west and lower in the east, decreasing from the land to the sea gradually. Rivers flow into the sea from the land with silt and sand which affects the development of coast and beach.

The coastline passes through different geological structures and geo-morphological unites which forms varied types natural environment and geological scenes. The continental coastline has the shape of letter “S” with NE-SW direction that controlled by Xinhuaxia geological structure. Hanzhou Bay is the boundary marker of China coastline.

The geological structure in the south has been rising all the time and formed hilly area with tortuous coastline by erosion. Nevertheless, the geological structure has been mainly descending,

such as Liaodong Bay, Laizhou Bay and Bohai Bay which formed plain coast sand extensive beaches.

Coral reefs and red forest coasts are along the China south coast.

2 TYPES AND CONDITIONS OF GEOLOGY AND GEO-MORPHOLOGY

2.1 Gravel Coast

Sand and gravel are main components of this kind of coast that is not in wide-spread in regional area. The materials of gravel coast were brought by rivers and eroded or collapsed substances from the coast. The gravel coast is of accumulation one. Sand dyke, sand dam and sand dune are common occurrences, especially along some of the sections of south coast.

In addition, the gravel coast can also be found in silt plain coast.

2.2 Bedrock Coast

Bedrock Coasts were formed in the eastern area of China where usually hilly area is and widely distributed. For instance, the bedrock coasts can be found in the north of Hanzhou bay of east China, Shandong and Liaodong peninsulas, mostly in the islands of Taiwan and Hainan. The length of this kind of coast is about 5000 km, accounting for 30% of the total one in China.

The unique features of geo-morphology of bedrock are as follows: On plain, the coastline is tortuous curvature. Bays and capes are distributed each other. Capes project into the sea with mainly erosion and bays go deep into the land with accumulation. On vertical plane, there is an undulating chain of mountains on the coast and sea water lashes the cliffs directly. There are different eroded geo-morphologies dispersed over the bedrock coast, such as, abrasion cliff, marine beach, abrasion platform, abrasion pillar and sea cave etc. (see Fig.2).

All of them were formed due to variety of hard and soft rocks, structures and fissures with external motive power.

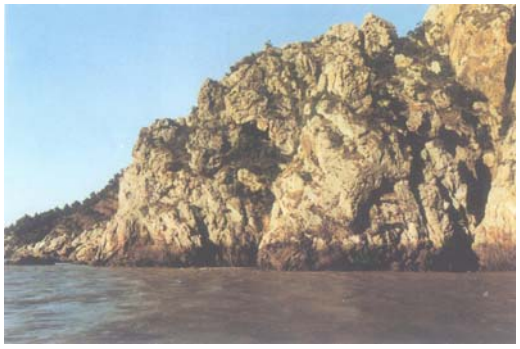

Fig.2 Sea cliff in Yuhuan Island of Zhejiang province

The sea erosion geo-morphologies are very popular in Dalian Xiaoping island of Liaoning province. The high of sea cliff is 40-50m by where abrasion pillar stands tall and upright. Karst features are the special ones in the province. On the contrary, there are few in Hebei province, only some of them are scattered in the north of Beidaihe, Qinhuang Island, and laolongtou.

The others are distributed in east and southeast of Shandong peninsula, lianyungang of Jiangsu province, south of zhenhaijiao of Zhejiang province, and somewhere of Fujian, Guangxi Zhuang Nationality Autonomous Region. Taiwan and Hainan provinces are these kinds of islands.

2.3 Silt Coast

Silt Coast consists of fine sands and silts where a vast plain was formed close to the continent and many rivers flow into the sea. On the river mouth area, ancient river course, lagoon and

wetland are distributed along the coast. The silt coasts are the main ones in China. The length is more than 4000 km, accounting for 22% of the totals where the land is fertile and is main base of grain field in China.

Silt beach has sinking in the long history period from the geological structure point of view.

The silt coast can be classified as coast of silt delta, silt plain and silt harbor. Among them, the silt delta coasts and silt harbors are famous distributed on the river mouth area of Changjiang, Yellow River, Zhujing, Haihe and Liaohe.

2.4 Coral Reef Coast

Coral Reef Coast is one of bio-coast that is widespread because of the tropical sea area in China.

Atolls and beach reefs are mainly in Taiwan Island, Hainan island, Penghu Islands and along the coasts of Guangdong, Guangxi provinces (see Fig.3).

Fig.3 Coral Reef Coast in Hainan coast

2.5 Red Forest Coast

Red forest Coast is. also the bio-coast that mainly distributed in the tropical and subtropical zones in south China and southeast area.

3 MAIN STRAITS AND ISLANDS IN CHINA COASTAL ZONES

3.1 Bo Sea Strait

Bo Sea Strait lies to the south of Liaodong peninsula on the opposite of Shandong peninsula, that is, the waterway is between the two peninsulas. The west of Bo Sea leads to the east of Yellow Sea.

Many islands are around the strait (see Fig.4), Miao Islands consist of 30 islands in northeast-southwest direction. Nanchangshan island has the area of 13km^2 that is the largest one in Bo strait. Daqin island is the highest one with an elevation of 202 m. The islands divide the strait into many waterways that are passageways for ocean current flowing in or out the strait.

Before12000years, the earth's crust rose and formed a land. After Holocene Epoch, earth's crust descended and formed the Bo Sea Strait gradually.

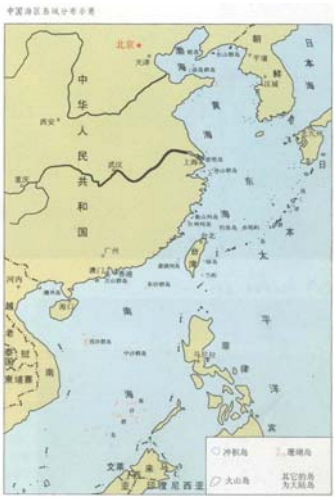

Fig.4 Sketch map of Islands distribution in China Coastal area

3.2 Taiwan Strait

Taiwan Strait is located in southeast of China that is the largest one in China.

The waterway of the strait is between the continent and Taiwan island, i.e., between Taiwan province and Fujian province with a northeast-southwest direction. The length is more than 500km in north-south and 150km average width in east-west. The strait links the East Sea and South Sea. Taiwan shallow beach is the shallowest one in the strait with the average depth of 60m.

Penghu Islands is the main island in the strait that comprises 64 different size of islands and formed by submarine volcano eruption before 200×10^4 years. Basalt is base rock in the islands.

The waterway between Taiwan Island and Penghu Islands is the deepest one with 200m in the strait.

3. 3 Qiongzhou Strait

Qiongzhou Strait is situated in the south China between Hainan island and Lei Zhou peninsula that is one of 3 large straits of China with 80km in east-west length and 29.5km in north-south width.

The Nandujiangdelta projects into the sea and forms the cape at the east end of south strait. There is no island is in the strait.

The Qiongzhou Strait joins the Beibuwan and sea area of Zhujiang mouth. It is the natural boundary of Hainan and Guangdong provinces.

The Qiongzhou Strait is located in the middle of fault depression between Hainan Island and Lei Zhou Peninsula by earth crust split and massif movement before $2500\times10^4\sim250\times10^4$years. Since 6000 years, the earth's crust movement have been rising and falling gradually.

4. MAIN BAYS AND HARBORS IN CHINA COASTAL ZONE

Hangzhou bay is a boundary of plain bay in the north and bedrock bay in the south of China. There are more than 150 bays with an area of $10km^2$ in China (see Fig.5).

Fig.5 Sketch map of Main harbors distribution of China

4.1 Dalian harbor

Dalian harbor is the biggest one in Bo Sea that is located at the south end of Liaodong peninsula over looking Yellow Sea on the east and facing the Bo Sea on the west. The harbor and Penglai of Shandong peninsula are on the opposite sides of the Bo Sea Strait.

Dalian is a geological structural basin that is surrounded by mountains in north, west and south. The coast is bedrock one. Sanshan island is outside the bay that is a natural protective screen of the bay and makes the bay calm and tranquil.

Dalian harbor is an ice- free port with wide area in more than $300km^2$ and 10m water depth (the deepest is 33m). There is no deposit in the harbor. It is a natural good harbor for opening to navigation throughout the year to all over the world and is also rich in tour resources and important international trade transit harbor

4.2 Tianjing harbor

Tianjing harbor lies to the west of Bo Sea. It is the largest harbor and the centre of economy

and communications in north China.

In recent year, it becomes international trade harbor and is called the “capital door” of state because the harbor has Yan Mountain to the north, Yellow River delta to the south and capital Beijing to the west.

Tianjing Harbor is a silt plain coast harbor.

4.3 Qingdao Harbor

Qingdao Harbor lies to the southeast of Shandong peninsula, overlooking the Yellow Sea on the east and facing Jiaozhou Bay on the west.

Jiao Zhou Bay is a geological structure bay and mainly a bedrock coast with part sand and silt.

The Qingdao Harbor is located among the capes. It is a fine natural deepwater harbor of China as well as an ice-free port.

4.4 Shanghai Harbor

Shanghai Harbor is in the middle of China coast and guards the sea mouth of Changjiang River. It is the largest hub port recently for it being located in the most developing economy and cultural area of east China. The coast along the harbor is called international golden coast.

4.5 Ningbo Harbor

Ningbo Harbor is older than Shanghai Harbor with almost 2000 years old in Tang Dynasty (618-907years). Businessmen came from Japan, Korea, Southeast Asia and Arabia for exporting Chinese tea, silk and ceramics. Zhoushan Iislands is a natural protective screen of the bay. This harbor will be the international comprehensive hub port with the Shanghai harbor in the north opposite.

4.6 Xiamen Harbor

Xiamen Harbor is by the sea of northeast of Fujiang coast. It is bedrock port in hill’s area and is an important harbor for exchanging trade with Taiwan.

4.7 Gaoxiong Harbor

Gaoxiong Harbor is an industry centre as well as the biggest port of Taiwan. It guards the southwest door of Taiwan and is an international port of west Pacific Ocean.

4.8 Hong Kong Harbor

Hong Kong Harbor is called “Orient Bright Pearl”. It is situated along the coast of the South Sea. It came into being after the continuation of continent splitting, submerging and sea water intrusion which made the Hong Kong Island separated from continent.

Port Victoria is the main port of Hong Kong with bedrock base mainly. It is calm due to Jiulong peninsula stretching towards south and into the sea.

Hong Kong port is the largest and maximum functions free port in the world. It is called three financial centre with New York and London ones.

5 VALUABLE OCEAN RESOURCES

General speaking, practically the ocean abounds varied resources that exist in the continent.

5.1 Petroleum and Gas

Sediments in all geological ages in the continental shelf of Bo Sea, Yellow Sea and East Sea are rich in petroleum and gas.

The 10 big oil and gas basins have been prospected in the basins of Bo Sea, north and south Yellow Sea, East Sea, west part of Taiwan, Zhujian mouth of South Sea etc. (see Fig.6).

According to data, the estimated oil reserve is about 22 ×108 ton and gas reserve 480×108m3 in 400 of oil structures in sea floor where the oil and gas accounts for 10%- 14% and 25%--34% of the total ones in China respectively and makes China as one of five oil producing countries.

There is great promise for the development of oil and gas in China.

Fig.6 Sketch map of oil and gas basins in coastal area of China

5.2 Coal and Iron – solid minerals

Copper, coal, sulphur, phosphorous and limestone are widely distributed in the shallow sea area of continental shelf of China.

5.3 Sand mineral resources in sea shore

China is one of the countries in the world that is rich in varied sand resources in the Sea shore, especially including the minerals of titanic iron ore, Zircon, Rutile, Monazite, phosphorus-yttrium, magnetite and sand-tin ore etc. that has industrial exploration value (see Fig.7) .

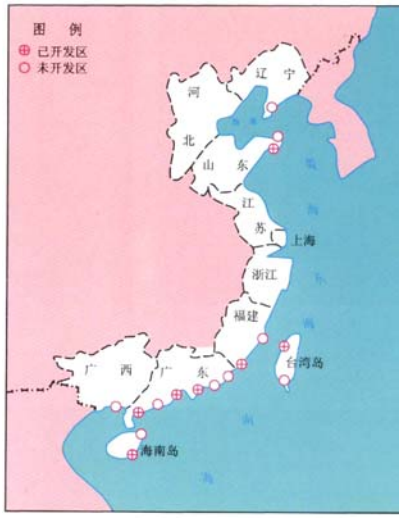

Fig.7 Sketch map of Sand Mineral Resources in Sea Shore of China

5.4 Multiple- Metal Nodule and Cobalt- Manganese Nodule

An area of 200 × 104 km^2 with Multiple-Metal Nodule and Cobalt-Manganese Nodule has investigated by China in Pacific Ocean.

Among that, 30×104 km^2 area has industrial exploration value and 15×10^4 km^2 area of which has allocated to China by United Nations (UN).

5.5 Hot Liquid Mineral

It is a kind of metal sulphide.

5.6 Inflammable ice

Inflammable ice is called natural gas hydrate-a new mineral. It is discovered in South Sea and East Sea of China. The estimated oil equivalent is about 700×10^8 ton in the South Sea that is equal to 1/2 oil reserve of china continent one in recent year.

The discovery of inflammable ice brings peoples with new hope under the situation of oil and gas exhaustion. In addition, the sea water-liquid chemical industrial resources can produce salt, fertilizer, bromine etc ; Ocean space can be used as electric power plant, sea water desalination plant and oil storage, airport, tunnel, military base; Medicinal treasure- house; marine traffic and scenic spot of tourists etc..

6 SEA CALAMITY AND ITS ENVI- RONMENTAL PROTECTION

EL Nino and La Nina, Typhoon, Wind-storm Tide are natural sea calamities.Red tide and sea level rising etc. are artificial disasters.Global environment deteriorating has drawn world-wide attention, such as, waste gas discharge (e.g. carbon dioxide (co2)), global temperature increasing, ozone layer damage, acid precipitation, fresh water exhausted and biological population dropped sharply.

6.1 Sea level rising

Sea level rising threatens seriously survival of countries along coast and island countries.

According statistic data, average surface temperature will rise 1.4～5.8 ℃ in 2100 comparing with that in 1990 in global. The area of sea ice will further reduce with sea level rising in 0.09 ～ 0.88m.

The sea level rising is usually caused by coastal city's development rapidly, and groundwater over pumping that induces land subsidence aggravatingly and then sea level rises except the cause of climate changing into warmer and earth's crust movement vertically.

Nevertheless, speed of land subsidence will be faster than sea level rising. The sea level rising will sharpen the disasters of windstorm tide, flooding, sea water intrusion, soil salinization, coastline erosion and wet land reducing etc. that will threatens the environment and mankind's activities.

6.2 Coast Erosion aggravation

According to the data, the windstorm tide and coastal erosion was aggravation around Bo Sea area and part of Hainan in 2001-2003.

The eroded coast was 20.9 and 28.8 km respectively in the coast of Liaodong, Shandong and Jiansu.

Some sections of coast fell back about 80m in eroded coast of Hainan area and the casuarina equisetifolia forest was disappeared.

6.3 Sea area pollution

Sea area pollution includes oil pollution and red tide.

The first tide was recorded in 1930's and increased up to 30 times abruptly in 1980's.

Based on the statistic data, the 12 km^2 of sea surface will be covered by 1 ton crude oil. The speed of it will be 100-300m/h and will make marine organism re-reproduction in 7-9 years.

According to the sea water quality standard in china, in recent year: Poor quality of sea water

(Ⅲ type): Accounting for 53.4%; (of the total sea water in China) Satisfied: 6.5%; Ⅱ type: 21.4%; Ⅰ type (good quality): 18.7%

The main pollutants are inorganic nitrogen, active phosphate and heavy metals.

6.4 Land Subsidence

Land subsidence is very serious in coastal area, especially along the economic developing area of eastern coast because of ground-water over pumping.

For instance, from 1958-1992, land subsidence sunk about 58cm that reduced tide protecting function of harbors in Tianjing.

There is 18000km coastline in China, the area of seashore and delta is vast with an elevation of 1.5 ～4.0m.

Among them, it is very fragile environment in the plain area of Liaohe, east China plain, Zhujiang delta, Guangxi seashore, Hainan and Taiwan. Especially the Zhujiang delta, Changjian River delta, Yellow River delta, Bo Sea Bay and Subei coast where are the economic developing area, are very responsive to the land subsidence and sea level rising.

6.5 Water running dry in river mouth

For instance, the lower reaches of Yellow River was dried up in length of 680 km during 227days in 1997 due to the surface water over use and ground water over- pumping which made **s**oil salinization and desertification in Yellow River mouth.

The same situation also happened in middle reaches of Huaihe River in 1999 that is very seldom seen in the history.

7 SOLUTIONS OF ENVIRONMENTAL PROTECTION

7.1 The state law and regulation of all kinds related to ocean and sea environmental protection must be improved and further worked out, particularly have to be put them into effect, such as, the law of liquid wastes discharging into the sea, reasonable groundwater pumpage limitation along the coastal area etc..

7.2 The sea level movement, earth's crust deformation, land subsidence, sea water intrusion etc. must be monitored continuously along the coastal area.

7.3 The over –exploitation of underground liquid (groundwater, oil and gas etc,) and high building construction have to be controlled in the coast area.

7.4 Wet land, diluvia plain and river mouth environment are required to be further safeguarded.

Finally, in the coastal area of China, **g**eological abundant resources are expected to be exploited and utilized further.

Many geological spaces and harbor constructions are waiting for utilization and development.

For geologists, so many tasks of hydro-geology and geology engineering study and investigation are expecting to be done along China coast.

The prospect of China coast development is boundless bright.

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