Introduction to the Yellow River Delta: origin, evolution, challenge and endeavor

Qingdao institute of marine geology (QIMG), CGS

Siyuan Ye
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Location & characteristic of Yellow River Delta

- Newly created wetland
- Second largest oil field
- National natural reserve
- Agriculture base
- Dynamic estuary
Yellow River delta since the end of Late Pleistocene (Xue, 2001)
Fig. 1. Simplified map showing shifts in the lower Yellow River (simplified after Zhou Yilin et al., 1982) and geomorphological and sedimentary provinces of the floodplain of the lower Yellow River. (A) Alluvial fan; (B) western plain; (C) middle plain; and (D) eastern plain (coastal deltas).
Fig. 2. Yellow River delta complex and shelly ridges in the western coastal lowlands of the Bohai Sea. The complex is composed of the following delta superlobes: (1) Lijin superlobe, inferred age 6000–5000 years B.P.; (2) Huanghua superlobe, inferred age 5000–4500 years B.P.; (3) Jugezhuan superlobe, inferred age 4500–3400 years B.P.; (4) Shajini superlobe, inferred age 3400–3000 years B.P.; (5) Nigu superlobe, 3000 (inferred)–602(?) years B.C.; (6) Qikou superlobe, 602(?) B.C.–A.D. 11; (7) Kenli superlobe, A.D. 11–1048; (8) Tangpu superlobe, A.D. 1048–1128; (9) North Jiangsu superlobe, A.D. 1128–1855; and (10) modern superlobe, A.D. 1855–present. Ages in legend are: Warring States, 475 B.C.–221 B.C.; Han Dynasty, 206 B.C.–A.D. 220; Tang Dynasty, A.D. 618–907; Song Dynasty, A.D. 960–1279 (modified after Xue and Cheng, 1989).
Fig. 3. Schematic diagram of the composition of the Yellow River delta complex.
Fig. 3. Schematic diagram of the composition of the Yellow River delta complex.
Origin

Some superlobes and drilling hole
Fig. 5. Cross-section through three imbricated delta superlobes of the Yellow River delta complex: Lijin delta superlobe, Kenli delta superlobe and the modern delta superlobe. For location of this section, see Fig. 4.

Cross section showing imbricating between delta superlobes. (Xue, 1993)
Origin

A block diagram showing the relationship of Holocene sedimentary environments. (Xue et al., 1993)
Abandoned channels on the modern Yellow River Delta (1855-present)

1. 1855-1889 (natural flood)
2. 1889-1897 (ice flood)
3. 1897-1904 (natural flood)
4. 1904-1917 (natural flood)
5. 1917-1926 (natural flood)
6. 1926-1929 (natural flood)
7. 1929-1934 (artificial channel)
8. 1934-1953 (artificial channel)
9. 1953-1960 (artificial channel)
10. 1960-1964 (artificial channel)
11. 1964-1976 (ice flood artificial channel)
12. 1976-present (artificial channel)
Evolution
River shifts and depositional pattern

1 Distributary channel
2 Crevassed fun
3 Flood plain
4 Distributary & crevassed fun
5 Low delta plain
6 Delta front
7 Distributary bay
8 Prodelta
9 Subaqueous delta of abandoned lobes
Evolution

Deposition thickness of the modern YRD
Evolution

Silt thickness of the modern YRD
The Diaokou delta lobe was formed before 1976. After 1976, the end river channel shifted to Qingshuigou course.

(From Yang Zuosheng)
Shift of the apex of the channels of the modern YR delta in 1934 limited the space of the delta evolution greatly.
Constraint shift of the river course happened in 1976 to create a new land in the area of a nearshore oil field and to build a port in the eroding northeast delta.
Evolution

The delta shifting direction was changed once more by human activities.
9.7bt of sediment will be stored in reservoirs during 30 years (from YRCC), so the sediments discharge to the delta was getting decreasing over time.
Evolution

No-flow days during 1950-2000
## Evolution

Sharp descending in water and sediment discharge over three stages

<table>
<thead>
<tr>
<th></th>
<th>Water discharge</th>
<th>Sediment discharge</th>
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<tbody>
<tr>
<td></td>
<td>Average (10⁸ m³)</td>
<td>Ratio (%)</td>
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<tr>
<td><strong>1950-1968</strong></td>
<td>501.5</td>
<td>100</td>
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<td><strong>1969-1985</strong></td>
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<tr>
<td><strong>1986-2001</strong></td>
<td>137.7</td>
<td>27.4</td>
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From YRCC
## Evolution

**Water and sediment discharge and the days without current**

<table>
<thead>
<tr>
<th>Year</th>
<th>W.discharge (10^8 \text{ m}^3)</th>
<th>S.discharge (10^8 \text{ t})</th>
<th>Days without current</th>
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<tbody>
<tr>
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<td>1977</td>
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<tr>
<td>1978</td>
<td>259</td>
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<td>346</td>
<td>11.5</td>
<td>10</td>
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<td>5.42</td>
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<td>1987</td>
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<tr>
<td>1988</td>
<td>196</td>
<td>8.49</td>
<td>5</td>
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</tbody>
</table>
### Evolution

Water and sediment discharge and the days without current (YRCC)

<table>
<thead>
<tr>
<th>Year</th>
<th>W.dischage</th>
<th>S.dischage</th>
<th>Days without current</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>242</td>
<td>5.99</td>
<td>24</td>
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<tr>
<td>1990</td>
<td>264.25</td>
<td>4.69</td>
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<tr>
<td>1991</td>
<td>122.54</td>
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<td>1992</td>
<td>133.74</td>
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<td>184.97</td>
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<td>1994</td>
<td>216.97</td>
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<td>1.85</td>
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<tr>
<td>2000</td>
<td>49.11</td>
<td>0.241</td>
<td>0</td>
</tr>
</tbody>
</table>
The red line shows the sediments accumulation value over the time at Lijin station;

The yellow columns show net deposit value within 15m depth.

1997 - 1999
Sediment deficit:
1.412bT
Comparison of coast line in different periods
Challenge

1. 3230 km$^2$ of new land formed from 1855 to present
2. Shoreline progress with a speed of 150m/a
3. About 100 km$^2$ land was submerged by erosion (Li, 2003)
Challenge

- The erosion-accumulation of the subaqueous delta was estimated based on the bathymetric measurements of 36 survey lines along the delta coast. (From Yang Zuosheng)
Erosion – accumulation of the delta area within the water depth of 15m from 1976-1999: 3 erosion centers in the north of the previous river mouth, 1 accumulation center in the present subaqueous area.

Erosion-accumulation amount: pure erosion of the delta happened in 1997.

(From Yang Zuosheng)
Challenge

1976-1994

shoreline of 1976
shoreline of 1994

Erosion center
Depocenter

(From Yang Zuosheng)
Challenge
The planned river courses are to east and to north. No any plan to southeastern way. It may be correct for control the courses and the further industry development. But for the wetland maintenance and delta growth, southeastern way is a good choice.
Challenge

- The scouring of the delta slope beneath the coastal dikes will continue and develop as the time passes by.
- The shallow trenches/ridges could be formed as long as more than hundred km long around the delta.

(From Yang Zuosheng)
As a consequence of the lack of water discharge from YR, the wetlands here experienced severe degradation. From 1984 to 2000, 8000 ha of reed were reduced, 33% was changed to farmland, 27% to Chinese Tamarisk, and 26% to Lalang grass. About 4000 ha of fresh water area was lost (Liu, 2001).
Challenge

Landuse changes in last 40 years

- 1956, digital topographic maps
- 1984, remote sensing
- 1991, 1:50,000 land survey
- 1996, remote sensing
Challenge

- The sediments or fresh waters loss represents more than just the loss of land. It represents the loss of what sustains much of the regional habitat, economy, culture, and national image.
Coastal dikes of about 130 km were built since 1986 to protect the coast from erosion.

(From Yang Zuosheng)
Impact of coastal dike constructions on the delta morphology

The coast dykes were built in 1986-1987 to protect the oil fields. New dikes were built in 2002-2004 in the southeast coast to protect the Dongying city. The natural balance shoreline of coast erosion-accumulation is replaced by the fixed coastline-dikes.
As one of the most important places for migrant birds in northeast Asia as well as the Asia-Pacific rim, the Delta has been put on both world and Chinese bio-diversity and wetland protection lists.

However, a shortage of water has caused the frequent drying-up of the lower reaches of the YR in recent years and posed a grave threat to the ecosystem at the estuary of the river.

In the face of water deficiency, the Yellow River conservancy committee has carried water and sediments adjustment since 2002.
<table>
<thead>
<tr>
<th>Year</th>
<th>Whole year</th>
<th>Water and sediment adjustment</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Flux (bm³)</td>
<td>Duration (days)</td>
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<tr>
<td>2002</td>
<td>4.189</td>
<td>25</td>
</tr>
<tr>
<td>2003</td>
<td>19.27</td>
<td>28</td>
</tr>
<tr>
<td>2004</td>
<td>19.88</td>
<td>35</td>
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<tr>
<td>2005</td>
<td>20.68</td>
<td>45</td>
</tr>
<tr>
<td>2006</td>
<td>19.17</td>
<td>21</td>
</tr>
</tbody>
</table>

(From YRCC)
Endeavor

Water and sand adjustment project

Q4 Q7 C2
The flow velocity of the river at 3 cross section (m/s)
Sand contents of the River at 3 cross section (kg/m³)

Endeavor

Sand contents of the River at 3 cross section (kg/m³)
80 million m$^3$ water and 20 mT sediments from the Yellow River has been stored in the wetland area when the sand-discharging project was undertaken.
• Origin
• In 1855, the Yellow River was broken at the Tong Wa Xiang, Henan province. The flood water of the Yellow River captured the course of the Daqing River to the Bohai Sea, where it created a new delta rapidly.
Summary

• Evolution
• major shifts in the course of the Yellow River have contributed significantly to the evolution of the YRD. Natural processes alone, however, are not responsible for all of this.
• Human activities such as construction of reservoirs in the drainage basin have reduced sediment supply for the healthy growth of habitat in the YRD. Draining and filling the sea for agriculture activities and oil exploitation have also been largely responsible for shaping the Delta.
Summary

- **The Erosion(1997-2002)**

  - The northern part of the delta had been constantly eroding since 1976. The accumulation had happened in the new delta-lobe area since 1976, but had turned to erosion since 1997. The whole delta had changed from the constructive phase to a destructive one as its water and sediment discharge to the sea decreased sharply during 1997-2002.

- **The shape**

  - The morphology of the delta will remain asymmetric. The shallow trenches/ridges on the subaqueous delta slope will develop.
The dyke

The coast dykes were built in 1986-1987 to protect the oil fields. More dikes were built in 2002-2004 in the southeast coast to protect the Dongying city. The natural balance Shoreline of coast erosion-accumulation is replaced by the fixed coastline fixed--dikes.
Summary

The Yellow River Delta had been shrinking by an average of 7.6 square kilometers a year during 1996-2002, according to the Shandong Provincial Bureau of Geology and Mineral Resources.

The river channel silting is not serious as the sediment discharge keeps continuously low.

Stabilization of the river course on the delta meets to the demand of local economic development and oil exploitation on the delta.

Small change of the river outlet could be happen.
Summary

80 million m³ water from the Yellow River has been stored in the wetland area when the water and sediment adjustment project was undertaken. Inflow of freshwater has eased the decline of wetland and extension of salinity and improved soil quality and water bodies in the wetland. At present, the Yellow River Delta Conservation Area has become a rare bird aggregating spot along eastern coast in China and bird species has increased from 187 to 283. Rare bird species, such as red-crowned crane, white-neck grey crane, white marabou have inhabited in the Delta.
Thank you