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# Depositional Process and Model of Fan Delta A Comprehensive Analysis of Modern Depositional System

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## Abstract

**There is a commonly held view that fan-delta plains contain intra-channels composed of coarse-grained deposits and inter-channels composed of fine-grained deposits. Moreover, it is thought that fan-delta plains are dominated by channels, with subaqueous channels in the fan-delta front. This paper reviews these ideas through an investigation involving the sedimentological characterization of a fan delta, detailing a comprehensive analysis of a modern and an ancient depositional system using a subsurface dataset of the Lower Triassic Baikouquan Formation in the Mabei area, Junggar Basin, and a flume tank experiment. The analysis reveals that fan delta deposition and construction is dominant in flood periods, whereas erosion and reworking of the plain is dominant in periods of low flow. Sheet flow sediments occupy the major portion of the fan-delta plain. Meanwhile, braided channels are typical of low-flow conditions. Both inter-channels and intra-channels are coarse-grained; fine-grained sediments, i.e., clay and silt, are mostly distributed in the outer-fan. Fan-delta front sediments are sheet-shaped along the shoreline, modified from the sheet flow of the fan-delta plain. There are no subaqueous channels in the fan-delta front. A comprehensive model of the fan delta in the study area has been constructed, which includes eight depositional types and microfacies. These have been recognized on the bases of color, rock texture, sedimentary structure, transporting medium, lithofacies association, distribution, and well log response. These findings suggest that many presumptions can be verified by this comprehensive analysis, providing a significant contribution to reservoir prediction and reservoir architecture of fan deltas.**

## Keywords

**Fan delta; Sedimentology; Depositional environment.**

## 1. Introduction

Holmes (1965) first defined the fan delta as an alluvial fan that has prograded from an adjacent highland into a standing body of water; either a lake or sea [1-2]. According to published literature, most fan deltas occur in tectonically active areas such as rift basins, pull-apart basins, and back-arc basins having coarse-grained clastic particles near the source [3-6]. However, a pronounced description of the depositional model, classification of facies, and an understanding of the energy conditions responsible for sediment distribution and the origin of brown mudstone in the fan delta are lacking. Some investigations have mechanically applied the depositional model of the river delta to the depositional model of the fan delta; in one example, the subaqueous channel of the river delta, ten kilometers long, was thought to be analogous to the fan delta, and so it was inferred that the inter-channels and intra-channels of the fan-delta plain have coarse-grained and fine-grained deposits, respectively [7-9].

## 2. Methods and Materials

Considering the origin of the fan delta and alluvial fan, an alluvial fan was chosen for the analysis of the sedimentary characteristics of the fan-delta plain [10-11]. The fan-delta plain has the same sedimentary characteristics as the alluvial fan [12-13]. It is therefore reasonable to consider an alluvial fan in the analysis of the sedimentary characteristics of a fan-delta plain.

The alluvial fan used in this study is located in the southern Junggar Basin, northwestern China, with its source lying north of the Tianshan Mountains. The Baiyang River transports high volumes of sediments from the Tianshan Mountains, forming the Baiyang River alluvial fan. The gradient of the Baiyang River alluvial fan is approximately 7° and covers an area of approximately 50 $km^2$.

This alluvial fan was delineated with eight survey lines comprising five parallel and three transverse lines along the source direction. Sediment characteristics and geomorphological parameters were acquired along these survey lines.

## 3. Results

Observation point Nos. 1–5 are located in the mountain pass of the Baiyang River, as part of the proximal fan. The proximal fan consists of two depositional units: the main channel and the conglomerate overbank.

Due to the down-cutting of the channel, the main channel is lower than the conglomerate overbank in terms of geomorphology. The main channel is about 20 meters wide, and consists of granules, pebbles, cobbles, and boulders without clay. The conglomerate overbank, the relative highland along the side of the main channel, is dominated by ungraded, poorly-sorted, and matrix-supported granule-boulder conglomerates.

Observation point Nos. 6–10 are located in the mid-fan. The mid-fan consists of two depositional units: the braided channels and the conglomerate overbank.

The channel begins bifurcated, and the depth of down-cutting in the mid-fan is smaller than the depth of down-cutting in the proximal fan. The width of the braided channels in the mid-fan is approximately 50 meters, which is wider than the channel of the proximal fan. The braided channels are dominated by pebbles and cobbles. The conglomerate overbank, the relative highland along the main channel's side, is dominated by ungraded, poorly sorted, matrix-supported granule-cobble conglomerate. It is similar to the conglomerate overbank of the proximal fan, but the size of sediments obviously is smaller.

Observation point Nos. 11–14 are located in the distal fan. The distal fan consists of two depositional units, the braided channels and the conglomerate overbank.

The channel divides into many branches, while the depth of down-cutting in the distal fan is smaller than the mid-fan. The width of the braided channels in the distal fan is approximately 70 meters. The braided channels are dominated by well-sorted and rounded cobble. The conglomerate overbank is dominated by ungraded, poorly-sorted granule-pebble conglomerates.

The depositional model of the Baiyang River alluvial fan has been established through the measurement of each observation point. The alluvial fan is divided into braided channels and the conglomerate overbank. The braided channels are dominated by well-sorted, clast-supported conglomerates. The larger the distance between the braided channels and the mountain pass, the finer the size of the sediments, the wider the braided channels, and the smaller the down-cutting of channels. The conglomerate overbank is dominated by poorly sorted, matrix- or clast-supported conglomerates, which mostly occupy the major portion of the fan-delta plain. The larger the distance between the conglomerate and the mountain pass, the finer the size of the sediments. These characteristics are observed in the two sections, A-A' and B-B'. Most of the fan is dominated by the sediments of the overbank, as the size of the sediments get finer from source to sink, and the channel widens and shallows with depth from source to sink.

## 4. Conclusion

(1) Deposition and construction of fan deltas are dominant in flood periods, whereas erosion and reworking are dominant in periods of low flow. Braided channels are characteristic of low-flow conditions. Sheet flow sediments mostly occupy the major portion of the fan-delta plain. Both inter-channel and intra-channel sediments are coarse-grained, whereas the fine-grained sediments, i.e., clay and silt, are mostly distributed in the outer-fan.

(2) There are no subaqueous channels in the fan-delta front. The sediments of the fan delta front are sheet-shaped along the shoreline, modified by the sheet flow of the fan-delta plain.

(3) A comprehensive model of the fan delta in the study area, including eight depositional types and microfacies, has been constructed. These have been recognized on the basis of color, rock texture, sedimentary structure, transporting medium, lithofacies association, distribution, and well log response.

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## References

[1] Allen, P.A., Armitage, J.J., Carter, A., Duller, R.A., Michael, N.A., Sinclair, H.D., Whitchurch, A.L., and Whittaker, A.C. 2013. The Qs problem: Sediment volumetric balance of proximal foreland basin systems. Sedimentology, 60(1): 102-130.

[2] Bai, Z. 1992. Formation and Evolution of Junggar Basin. Xinjiang Petroleum Geology. 13(3):191-196.

[3] Brian, K.H., and Schmitt, J.G. 1996. Sedimentology of a lacustrine fan-delta system, Miocene Horse Camp Formation, Nevada, USA. Sedimentology, 43(1): 133-155.

[4] Cabello, P., Falivene, O., Lopez-Blanco, M., Howell, J.A., Arbues, P., and Ramos, E. 2011. An outcrop-based comparison of facies modelling strategies in fan-delta reservoir analogues from the Eocene Sant Llorenc del Munt fan-delta (NE Spain). Petroleum Geoscience, 17(1): 65-90.

[5] Jin, Z.K., Yan, L.I., Gao, B.S., Song, B.Q., Yu-Hang, H.E., Shi, L., and Gui-Zi, L.I. 2014. Depositional Model of Modern Gentle-slope Delta: A case study from Ganjiang Delta in Poyang Lake. Acta Sedimentologica Sinica, 32(4):710-723.

[6] Jin, Z.K., and Miao, H. 2011. New Understanding of Delta Depositional Model. Xinjiang Petroleum Geology, 32(5):443-446.

[7] Jones, S.J., Arzani, N., and Allen, M.B. 2014. Tectonic and climatic controls on fan systems: The Kohrud mountain belt, Central Iran. Sedimentary Geology, 302(4): 29-43.

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[8] Larsen, V., and Steel, R.J. 1978. The sedimentary history of a debris-flow dominated, Devonian alluvial fan-A study of textural inversion. Sedimentology, 25(1): 37-59.

[9] Leeder, M.R., and Gawthorpe, R.L. 1987. Sedimentary models for extensional tilt-block/half-graben basins. Geological Society London Special Publications, 28(1): 139-152.

[10] Lei, Z.Y. 2005. Characteristics of fan forming and oil-gas distribution in west-north margin of Junggar Basin. Acta Petrolei Sinica, 26(1): 8-12.

[11] Nemec, W., and Muszynski, A. 1982. Volcaniclastic alluvial aprons in the Tertiary Sofia District (Bulgaria). Annales Societatis Geologorum Poloniae, 52:239-303.

[12] Nemec, W., and Steel, R.J. 1984. Alluvial and coastal conglomerates: their significant features and some comments on gravelly mass flow deposits. Canadian Society Petroleum Geologists, 10: 1-31.

[13] Park, M.E., Cho, H., Son, M., and Sohn, Y.K. 2013. Depositional processes, paleoflow patterns, and evolution of a Miocene gravelly fan-delta system in SE Korea constrained by anisotropy of magnetic susceptibility analysis of interbedded mudrocks. Marine Petroleum Geology, 48: 206-223.