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Geomorphology Processes of Channel Planform Migration on Meandering Rivers

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1 Introduction

Morphological analysis on the planform migration structure of meandering river is an important basis for the reconstruction of evolution of paleochannel. Besides, it is a significant method for restoration of rivers through the important historical record of migration processes (Blum et al., 2013; Lin et al., 2017; Kasvi et al., 2017). Despite large numbers of literatures from both modern and ancient depositional systems of fluvials, analyzing the dynamic geomorphology evolution of meandering rivers remains a challenge (Willis and Tang, 2010).

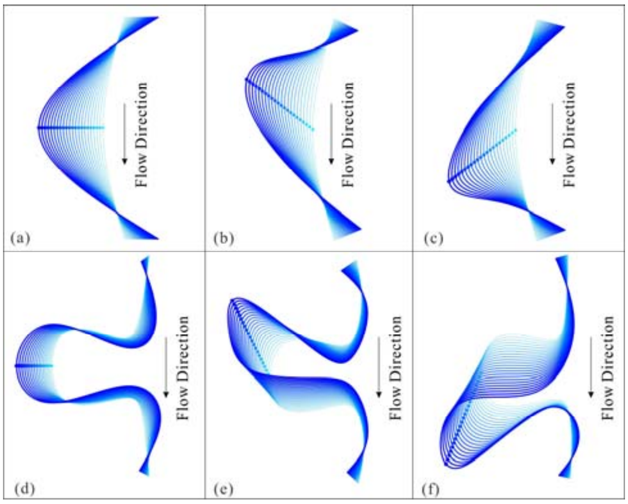

Fig. 1. Geomorphology planform migration processes of meandering channel under ideal conditions.
(a), Symmetrical expansion structure; (b), Upstream rotation expansion structure; (c), Downstream rotation expansion structure; (d), Symmetrical constriction structure; (e), Upstream rotation constriction structure; (f), Downstream rotation constriction structure.

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Attempts have been done to reconstruct the characteristics of palepchannel by understanding the planform migration structure of channel and evolution of dynamic geomorphic process (Ielpi and Ghinassi, 2014; Ghinassi et al., 2014; Wu et al., 2016). Although researches about the morphology and migration of meandering channels are attempted (Schuurman et al., 2016; Rousseau et al., 2016), it still remains poorly undefined how to account for the processes of migration structures.

This article mainly examines the planform migration of meandering channels, principally aiming to get through the problem of characterizing the migration morphology through the meticulous characterization on Irtysh River and Nowitna River, which are both well preserved in natural structure.

2 Planform Migration Structures of Meandering Channels

2.1 Structural elements

Systematic structural elements of migration structure is foundation for explicating the geomorphology processes. Thus, based on the research for Irtysh River and Nowitna River, 28 structural elements have been proposed in this article and crucial datas can be get from the table 1.

2.2 Planform migration structures

Combined with modern satellite image technology from the Google Earth and ACME Mapper, structure characterizations have been conducted on the 12 meanders with a new way of utilisation of new depictive parameters: downstream deflection angle (Δθ), countercurrent deflection angle (Δθ) and expansion factor (K_M).

By utilising the parameters and structural elements, 12 kinds of planform migration structures are figured out for the two rivers. Moreover, 6 kinds of conventional structures are proposed (Fig. 1), they are symmetrical expansion, upstream rotation expansion, downstream rotation expansion, symmetrical constriction, upstream rotation constriction and downstream rotation constriction structure. Besides, more complex patterns could be get by these combinations and there is still many new architectures. Therefore, there are certain limitations on the method of describing the structural characteristics and thus general application of planform migration structures to rivers still needs further studied in the future.

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Table 1 Structural elements statistics of the 12 meandering loops in the study area

Structure	Irtysh River						Nowitna River					
Bend	1	2	11	18	31	38	18	29	30	36	41	50
Latitude	58°52'N	58°56'N	59°20'N	59°34'N	60°14'N	60°40'N	64°45'N	64°41'N	64°42'N	64°40'N	64°39'N	64°35'N
Longitude	68°47'E	68°50'E	68°52'E	69°17'E	69°48'E	69°52'E	154°20'W	154°26'W	154°28'W	154°33'W	154°30'W	154°21'W
W_M/m	16520	14479	13068	14855	10522	22592	9299	10283	10327	12014	10044	8770
W_L/m	302741	302741	302741	302741	302741	302741	55458.0	55458.0	55458.0	55458.0	55458.0	55458.0
W_{SM}/m	12263.0	9765.0	2467.3	12230.8	7394.3	13075.5	1774.7	4111.8	3941.5	1873.8	3201.4	2217.4
W_{SL}/m	11094.8	11813.2	8409.4	23525.6	17068.8	18441.5	3660.9	6970.9	7339.3	6217.5	7918.2	3336.5
ML_M/m	3821.3	2541.6	1758.1	3225.5	2642.6	3309.8	654.8	1022.0	2269.6	700.2	715.9	592.0
ML_L/m	919.7	2472.9	3551.9	7637.9	2282.7	3145.0	727.9	1078.1	1186.1	684.8	1221.3	425.6
L_C/m	10166.9	7305.9	4626.3	11994.3	6999.2	6315.5	1608.9	2487.3	4578.9	1884.5	2300.0	1547.8
R/m	2155.3	1389.6	729.7	2148.5	1318.1	1311.9	300.1	465.8	866.5	355.3	456.6	296.9
$\|AX_M\|$/m	919.7	2472.8	3551.9	7637.9	2282.7	3145.0	727.9	1078.1	1186.1	684.8	1221.3	425.6
AX_M/°	344.3	103.7	211.8	226.9	49.7	336.5	237.2	292.3	278.6	279.8	109.8	130.9
AX_{ML}/°	44.0	136.9	311.9	94.4	316.8	110.1	143.7	174.2	311.2	16.8	58.5	29.3

Note: W_M: width of meandering belt, W_L: length of meandering belt, W_{SM}: migration width of single meandering channel, W_{SL}: migration length of single meandering channel, ML_M: width of single meandering loop, ML_L: length of single meandering loop, L_C: length of channel centerline, R: radius of curvature, $|AX_M|$: length of meandering belt axis, AX_M: direction of meandering axis, AX_{ML}: direction of meandering loop axis.

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