RIVER MORPHOLOGY AND CHANNEL PROCESSES

Iware Matsuda
College of Economics, Kanto Gakuin University, Yokohama, Japan

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Contents

Summary

Channel processes reflected in river morphology are erosion, transportation and sedimentation. These processes develop drainage basins. Every drainage basin has its own shape. Some indices are proposed to explain the shape of a drainage basin quantitatively. As for channels in a drainage basin, concept of stream order is introduced and is related to the total length and the gradient of channels and the area of drainage basins. A drainage pattern means a plan of a river system, and reflects a variety of information about geology and predominant slope of the drainage basin. Sediment loads are classified into bed load and suspended load. In contact with a river bed, bed load consisting of material of larger diameter than fine sand, is brought to the lower reaches. Fine materials such as clay and silt are held in suspension in stream water and are carried without contact with the river bed. The three main channel patterns in alluvial plains are: braided, meandering and straight. Channels on an alluvial fan show a braided pattern, and their depth is shallow. The river bed is composed of gravelly deposits. Channels in a flood plain meander and have a river bed composed of sand. Channels bifurcate in a delta, and bifurcated channels have muddy

river beds and tend to be straight. The movement of water and the kinds of sediment load affect the depth and width of a channel.

1. Introduction

Rain water flowing down slopes comes together to form a stream flow. The space where a stream flow runs is a channel. A river is the general term for a channel and the water in it. The area supplying water into a channel is a drainage basin. The boundary between drainage basins is a water divide. A river system is composed of the main stream and many tributaries. However, there are many cases where several tributaries have similar length and flow, and it is difficult to determine which is the main stream. A drainage pattern is a plan of a river system. A river develops various landforms through channel processes. The main channel processes or fluvial processes are erosion, transportation and sedimentation. Erosion predominates in the upper reach area of a drainage basin, and valleys composed of channels and slopes are formed. The materials brought to the lower reaches in a channel are sediment load. Weathering of the rocks composing slopes is the main cause of production of sediment load. Sediment load is deposited to form an alluvial plain. Three basic channel patterns are detected in alluvial plains. They are braided, meandering and straight. River morphology is explained by channel patterns and channel forms, and is decided by such factors as discharge, water surface slope, water velocity, depth and width of the channel, and river bed materials, etc. These factors are not independent but inter-related to each other.

2. Channel processes

2.1. Erosion

Running water carries out two processes. One is erosion and the other is corrosion. Erosion is a hydraulic action and is derived from the energy of running water. Gravel being brought by running water scours the channel and removes sediment from the river bed. Erosion makes a channel broader and deeper. These processes are also called lateral erosion and deepening erosion respectively. If deepening erosion predominates, a canyon is formed. Lateral erosion forms a channel with a broader river bed. Stream water reacts chemically with rocks and dissolves them. This process is called corrosion. Karst landforms composed of calcareous limestone provide a well-known example created mainly by corrosion.

Valleys in mountains can be very deep. Deep valleys are formed not only by stream water but also by the effects of weathering. The rocks composing slopes have been weathered for a long period of time, and become rock fragments or rock wastes including other fine materials. Gravity, in combination with heavy rain falling on the slopes, causes the weathered materials to fall down into the valley bottom. These process result in downstream extension of the valley and retreat of the upper slopes. The weathered materials deposited in a valley bottom are scoured by running water and carried to the lower reaches.

2.2 Transportation

The higher the water velocity, the more capacity a river has for transporting sediment load. There are three different processes in transporting sediment load. They are corrosion, suspension and traction. Corrosion is the process in which stream water corrodes rocks and brings them invisibly into solution. Such fine materials as clay, silt, fine sand and materials lighter than water are transported in the water or on the water surface without contact with the river bed. This process is called suspension, and materials carried in suspension are the suspended loads. Suspended load creates the turbidity of stream water. Gravel of larger diameter slides or rolls, and sand hops or bounds on a river bed. These processes are called traction. Sediment load carried by traction is known as bed load.

2.3 Sedimentation

A flood caused by heavy rain carries a huge volume of bed load from mountains to the plain. When a flood flows from the mountains to a plain, the capacity to transport bed load is suddenly reduced. Particles of bed load are deposited in order of their size, and an alluvial plain is formed. An alluvial fan composed of gravel is formed in the uppermost reaches of an alluvial plain. The surface of an alluvial fan is like a segment of a cone. The radial profile toward the lower reach is concave and the cross-sectional profile is convex. A delta being developed near a river mouth consists of fine materials and sand. The morphology of a delta is derived from the interaction of fluvial and marine processes. If neither of these two processes is superior to the other, an arcuate delta is likely to be formed. This form indicates a state of maturity in a delta. In the case of sediment load entering a calm bay, a 'bird foot delta' is developed. In some cases, strong coastal currents and sea waves move the sediment supplied by river, and a cuspate delta with several lines of sand bar can form. A flood plain consisting of natural levees and back swamps occupies the transitional area between an alluvial fan and a delta. A natural levee is composed of sand and silt. Clayey deposits distribute in back swamps are lower and wetter than natural levees.

The channels on an alluvial fan are interconnected and show a braided pattern. When a large flood flows down from mountains, the channels on an alluvial fan often change their course, and the newborn channel is maintained until the next flood. The former channel is abandoned and is supplied water only by groundwater. The lower reaches of the abandoned river remain as a feature on floodplains and deltas. Figure 1 is the landform classification map of Nobi plain, Aichi prefecture, in central Japan. The Kiso, Ibi and Nagara Rivers develop the plain. Since an active fault runs between the plain and the western ranges, the western part of the plain is down-faulting and very flat lowland is formed. Typical landforms in an alluvial plain are distributed along the Kiso River, flowing into the plain from the northeastern mountains. They are the alluvial fan, natural levees, back swamps and the delta. Many abandoned channels flowing down from the alluvial fan can be detected in the lower reach area.

2.4. A Graded River

As erosion proceeds, the gradient of a river bed becomes progressively gentler, and the energy of running water decreases. Eventually the capacity of running water for transporting sediment load will come to match the supply. In this condition, neither

erosion nor sedimentation occurs on the river bed and its gradient does not vary. Such rivers are named graded rivers. Although the gradient of a river bed does not change, the materials composing the bed are removed and replaced. The gradient of a river bed of a graded river decreases gradually towards the lower reaches, and the longitudinal cross-section of the channel conforms almost to an exponential line. When a sudden change occurs in the gradient of part of a channel, almost all the river system might be affected. Such changes can be natural or human–made, such as construction of dikes and bridges; these changes break the state of equilibrium.

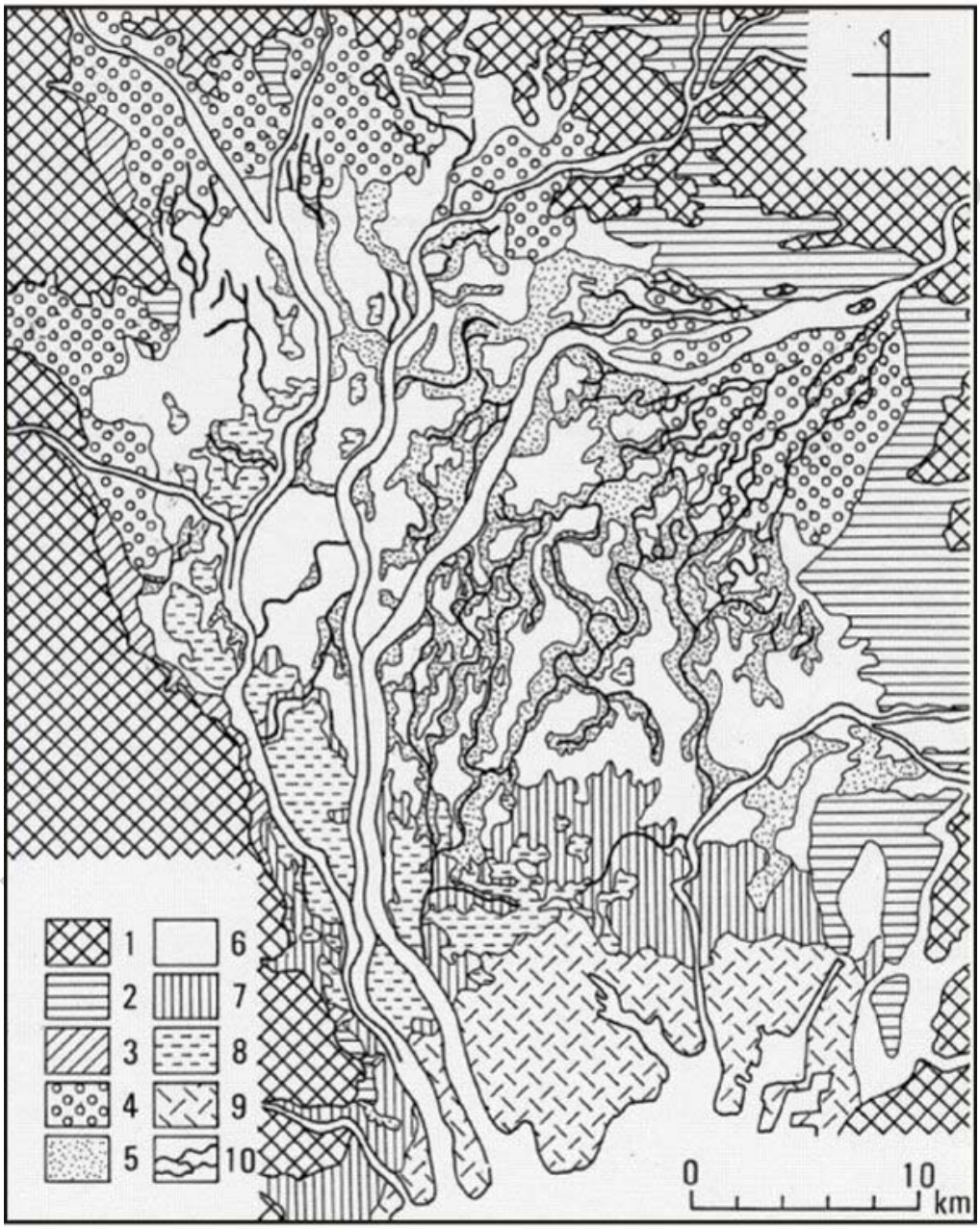

Figure 1. Landform classification of Nobi Plain.
1: mountain and hill; 2: river terrace; 3: alluvial cone; 4: alluvial fan; 5: natural levee; 6: back swamp and river course; 7:higher delta; 8: lower delta; 9: reclaimed land; 10: abandoned channel.

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Biographical Sketch

Iware Matsuda majors in geomorphology and Quaternary geology. His special theme is the historical development of alluvial plains. He was on the staff of the Department of Geography, Faculty of Science, Tokyo Metropolitan University from 1965 to 1992. In 1992, he moved to College of Economics, Kanto Gakuin University. He has been Dean of the College since 2000. At the university, he lectures on applied geomorphology, focusing on analysis of natural hazards from a geological and geomorphological point of view.

He has been a member of the Committee of Earthquake Hazard Assessment of the Tokyo Metropolitan Government for many years. He has been engaged in assessment of earthquake damage in Tokyo Metropolis and other self-governing bodies. He has visited many places which suffered from flood damage as well as earthquake damage. His study fields are not restricted to his own country. He has carried out field surveys in Bangladesh, Mexico, New Zealand, Philippines, Spain, Turkey, USA, and Venezuela, among others.