Active Tectonics and Alluvial Rivers

by S.A. Schumm, J.F. Dumont, and J.M. Holbrook, 2000; Cambridge University Press, 40 West 20th Street, New York, N.Y. 10011-4211 USA; 276 pages, hardbound; $80.00; ISBN 0-521-66110-2.

Rivers are among the most prominent landscape features. Their impact on sedimentology, geomorphology, hydrology, ecology and economy can hardly be overestimated; yet we still don't understand rivers completely in spite of over a century of detailed research. River complexity has two major sources: (1) complex internal dynamics and (2) complex response to external forcing. To make things worse, these are intertwined. For example, if river discharge is increased significantly, the river may react by (1) faster flow, (2) channel widening, (3) channel deepening, or (4) all 3 above. Our current knowledge of which variables will adjust how much is not much beyond the level of log/log plots with straight lines through a cloud of data points, derived from incommensurable sources. The most prominent external forcing factors determining river style and behavior are climate and tectonics. Climate has been widely recognized as an important factor for a long time: periglacial rivers are quite different from semi-arid ones, although both are characterized by highly variable discharges. A truly systematic review of the impact of tectonics on river dynamics, on the other hand, was hitherto non-existent.

This book is the first to present a comprehensive overview of the coupling between tectonics and river systems. The title has a profound meaning because *bed-rock* rivers, in contrast to *alluvial* ones, are generally highly confined and constrained in their ability to adapt to tectonic activity, so that alluvial rivers show the most pronounced and fastest (some thousands of years) adaptation. Past tectonic activity is not likely to leave tracks in contemporary alluvial river systems, and thus is less important than active tectonics, although past tectonics do define the context.

The book is divided into four major parts. Part I sets the scene by providing a thorough overview of river adaptation styles and modes of tectonic activity, accompanied by examples from the field and laboratory. Changes in river platform, longitudinal profiles, and terrace formation are discussed. Part II is a counterpart of parts III and IV; it has a forward approach and discusses the effects of known tectonic forcing, while parts III and IV infer tectonic activity from observed river adjustments.

Part II deals with the effect of known tectonic activity. Chapter 3 presents flume experiments where the impact of doming, subsidence, tilting and unloading on braided and meandering channels as well as on complete drainage networks is studied. Chapter 4 presents case studies where tectonic movements were measured by means of repeated high-precision surveying, and compared with observed river adaptation. Chapter 5 discusses the impact of earthquakes, which can be quite dramatic.

Part III investigates how observed river adjustment to unknown external (tectonic) forcing might be used to infer knowledge about these forcing factors. Chapter 6 presents case studies and compares four rivers with respect to tectonically induced erosion and deposition. River behavior is not consistent in all respects: channel width and depth, for instance, change inconsistently, but their *ratio* is consistent, i.e. increasing in erosional reaches and decreasing in depositional reaches. Chapter 7 discusses the impact of tilting on channel location; rivers may shift or avulse, or both. It is shown that tectonics are the ultimate driving force behind channel migration, but that climate controls whether any migration will take place.

Part IV applies the data from the previous chapters to sedimentology, structural geology and engineering. The impact of tilting, uplift and subsidence on fluvial architecture is reviewed in chapter 8.
Chapter 9 gives examples from the Mississippi and the Nile, where downstream patterns in sinuosity, gradient, channel-belt width, etc. were used to identify structural features such as local uplifts, faulting or heights in the underlying bedrock. A novel approach is combining channel cross-sections and sophisticated hydraulic modeling techniques to identify anomalies in the water-surface gradients, caused by crossing to a downthrown block. Methods like this might assist identification of neotectonic structures without any *a priori* knowledge of the subsurface geology. Finally, it is stressed that alluvial rivers are highly sensitive to subsidence caused by tectonics, compaction and groundwater or petroleum withdrawal. Good insight into river behavior is therefore required for site constructions, canal management, and flooding.

Overall, the book is highly readable and well illustrated. It provides a wealth of field evidence and experimental results. It is, as far as I am aware, the only one of its kind and is therefore a must-read for workers in fluvial sedimentology, structural geology, and civil engineering. After having read the book, I realized, however, that I had missed an overall theoretical framework that firmly establishes cause/effect relationships. This is not really a surprise, since we still do not really *understand* rivers from a theoretical point of view. Obviously, a more fundamental treatment of the subject is inevitable. The field and lab have spoken now, but theory cannot remain silent.

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