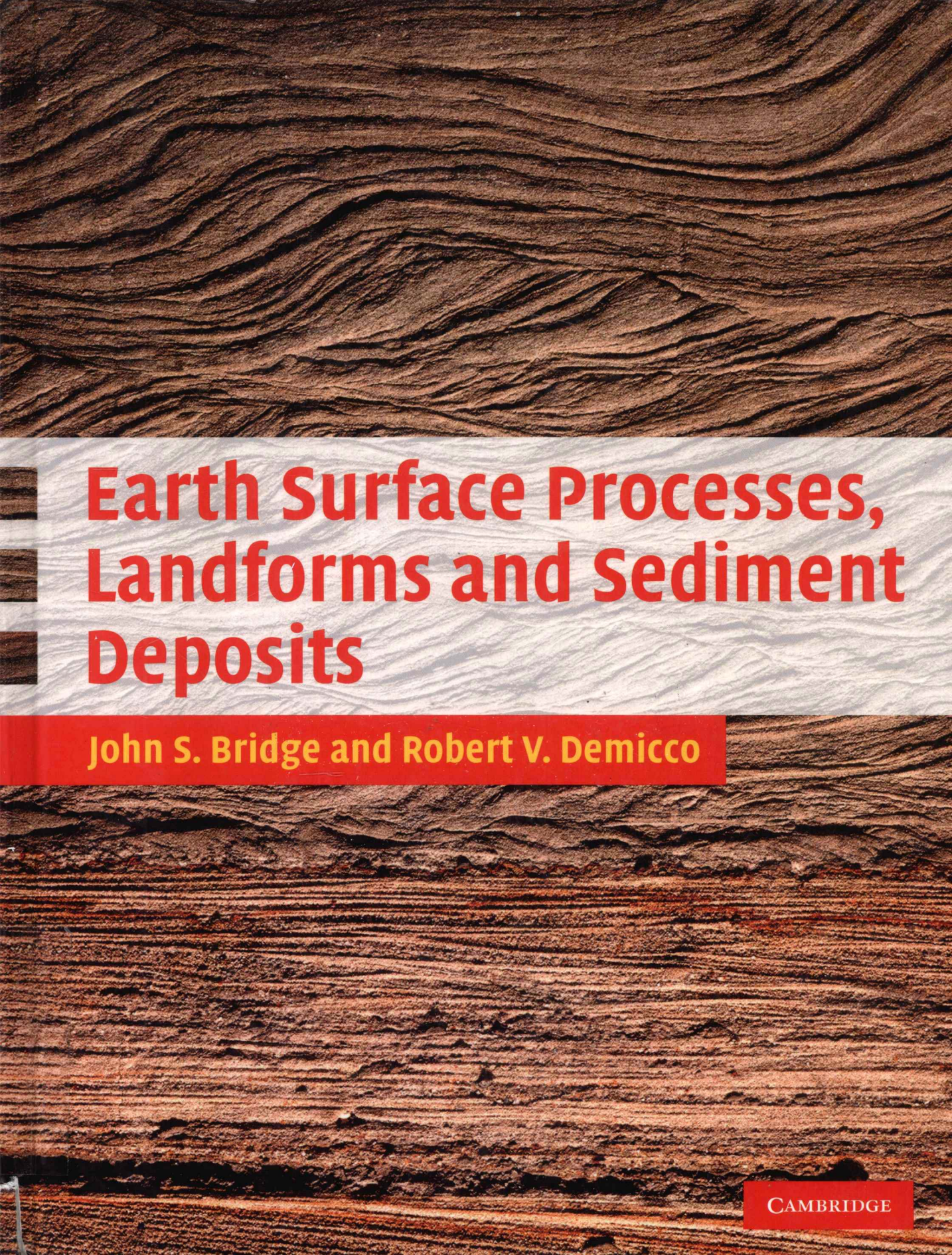

Earth Surface Processes, Landforms and Sediment Deposits

John S. Bridge and Robert V. Demicco

CAMBRIDGE

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Part I
Introduction

1 Definitions, rationale, and scope of the book

Definition of terms

Earth surface processes include weathering; sediment production by weathering and biochemical or chemical precipitation; erosion, transport, and deposition of sediment under the influence of gravity, flowing water, air, and ice; earthquakes and Earth surface motions; volcanic eruptions and movement of volcanic ejecta. Study of the landforms (morphology) of the Earth's surface, including the processes responsible for such landforms, is called *geomorphology*. The study of sediment, specifically the nature and origin of unconsolidated sediments and consolidated sedimentary rocks, is called *sedimentology*. *Stratigraphy* strictly means the description of (sedimentary) strata, which, by definition, is another aspect of sedimentology.

Importance of Earth surface processes

Earth surface processes are important for scientific, engineering, environmental, and economic reasons, as explained below.

Shaping of the Earth's surface

Many of the Earth surface processes responsible for landforms involve the formation, erosion, transport, and deposition of sediment (Figure 1.1). It is impossible to understand the formation of depositional landforms (such as deltas and beaches for example) without knowledge of the sediments that compose them. Furthermore, the nature of sedimentary deposits is likely to be related to the processes of sediment production and erosion in the source area. Therefore, the disciplines of geomorphology and sedimentology are intimately related.

Interpretation of ancient surface processes, landforms, and sedimentary deposits

The only rational way of interpreting the origin of ancient sedimentary deposits (Figure 1.2) is to compare them with modern sedimentary deposits, or with theoretical models based on knowledge of modern sedimentary processes. Then, the sedimentary record can be interpreted in terms of past Earth surface processes and landforms, leading to reconstruction of the geography, tectonics, and climate of the past (i.e., Earth history). Evolution of life on Earth and the habitats and lifestyles of past organisms are also reconstructed from the fossil evidence preserved in sedimentary deposits.

Knowledge of Earth surface processes, landforms, and sedimentary deposits is being used increasingly to interpret the present and past surface environments on other planets (e.g., Mars), and such interpretation requires particular care in view of the different physical, chemical, and biological conditions on other planets.

Engineering, environmental, and public-safety issues

Many Earth surface processes involve engineering, environmental, and public-safety issues, including landslides and debris flows; river floods; storm surges; riverbank and beach erosion; sedimentation in navigation channels; ground movements, landslides, and tsunamis associated with earthquakes; eruptions of volcanic ash and lava, and their effects on climate, river floods, and sediment gravity flows (Figure 1.3). Earth surface processes must be understood when constructing anything on the Earth's surface: buildings, roads, railways, canals, dams, coastal barrages

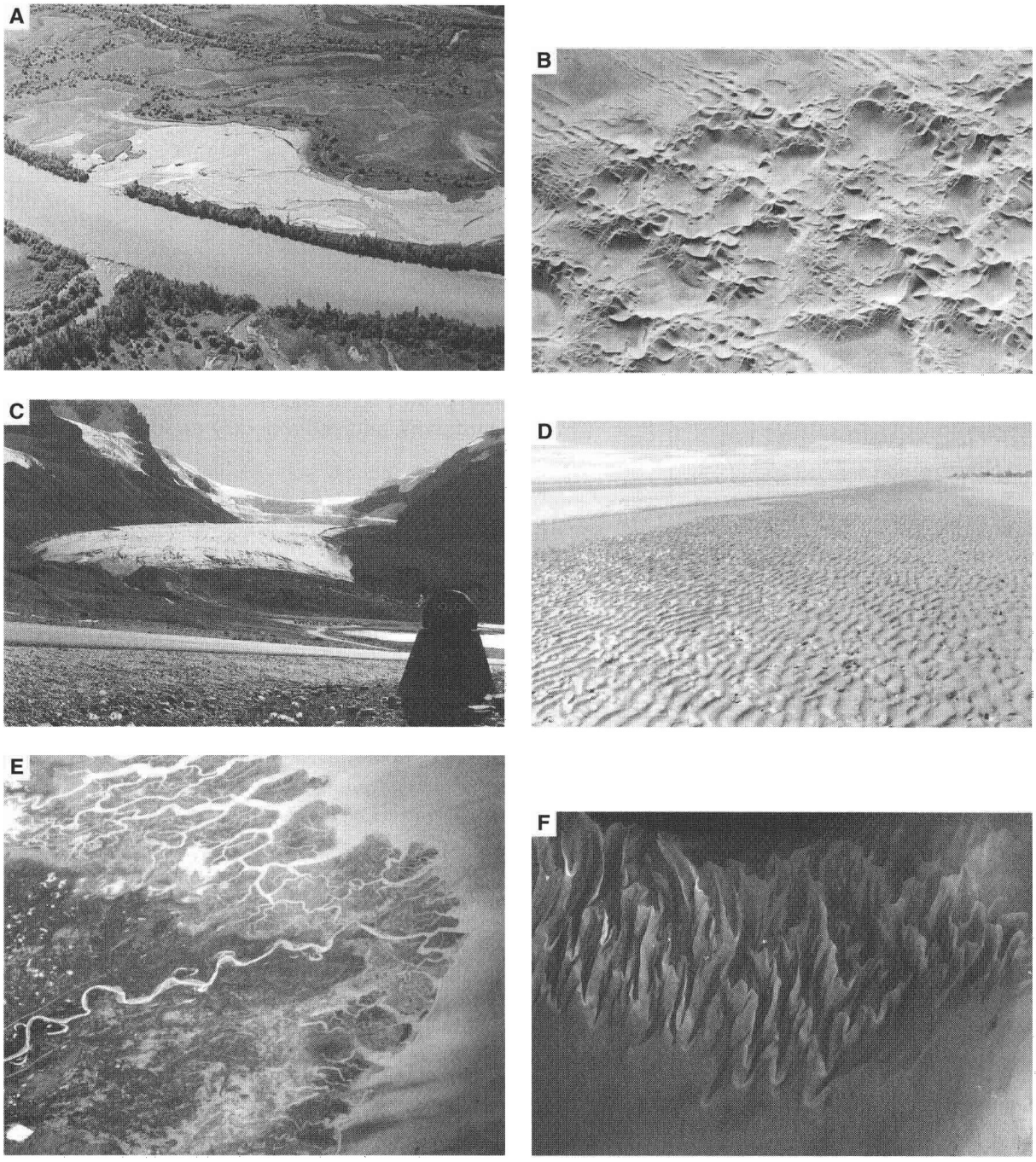

FIGURE 1.1. Depositional landforms. (A) Channels, levees, and crevasse splays on the Columbia River, BC, Canada. Photo courtesy of Henk Berendsen. (B) Issaouame sand sea in eastern Algeria. From NASA Earth from Space. (C) Athabasca Glacier, Canada, showing marginal deposits and the position of the terminus in 1919. Photo courtesy of Henk Berendsen. (D) Beach with ridge and runnel, Galveston Island, Texas. Photo courtesy of Robert Tye. (E) The Indus River delta. From NASA Earth from Space. (F) Carbonate-sand tidal sand shoals from the Bahamas. From Earth Science World Image Bank. (See Plate 1 for color versions.)

(Figure 1.4). Earth surface processes must also be understood when repairing human damage to Earth's surface environment: e.g., restoration of natural ecosystems; remediation of polluted water and air.

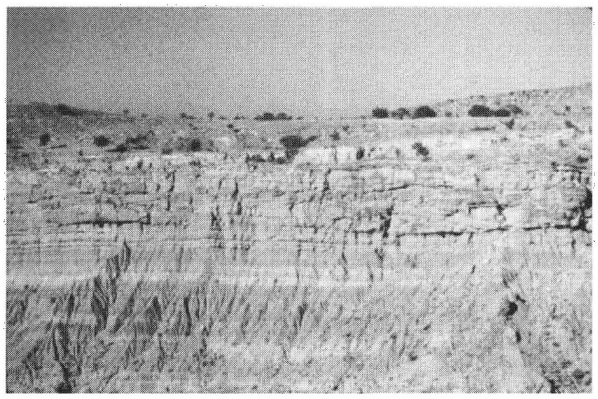

FIGURE 1.2. A large outcrop of sedimentary rocks from the Miocene Siwalik Group, northwest Pakistan. (See Plate 2 for color version.)

Economic resources in sedimentary deposits

Knowledge of sedimentary deposits is essential for the exploration, development, and management of economic resources that they contain: water, oil, and gas in their pore spaces; stone, sand, and gravel for building; clay for pottery and bricks, and as a source of aluminum and iron; limestone for cement; evaporite minerals; coal and lignite; placer minerals such as gold (Figure 1.5).

Rationale and scope of the book

It is clear that Earth surface processes, landforms, and sedimentary deposits are intimately related. They have a fundamental bearing on understanding Earth history; modern engineering, environmental, and public-safety issues; and exploitation and management of economic resources in sedimentary deposits. Geomorphologists, sedimentologists, environmental

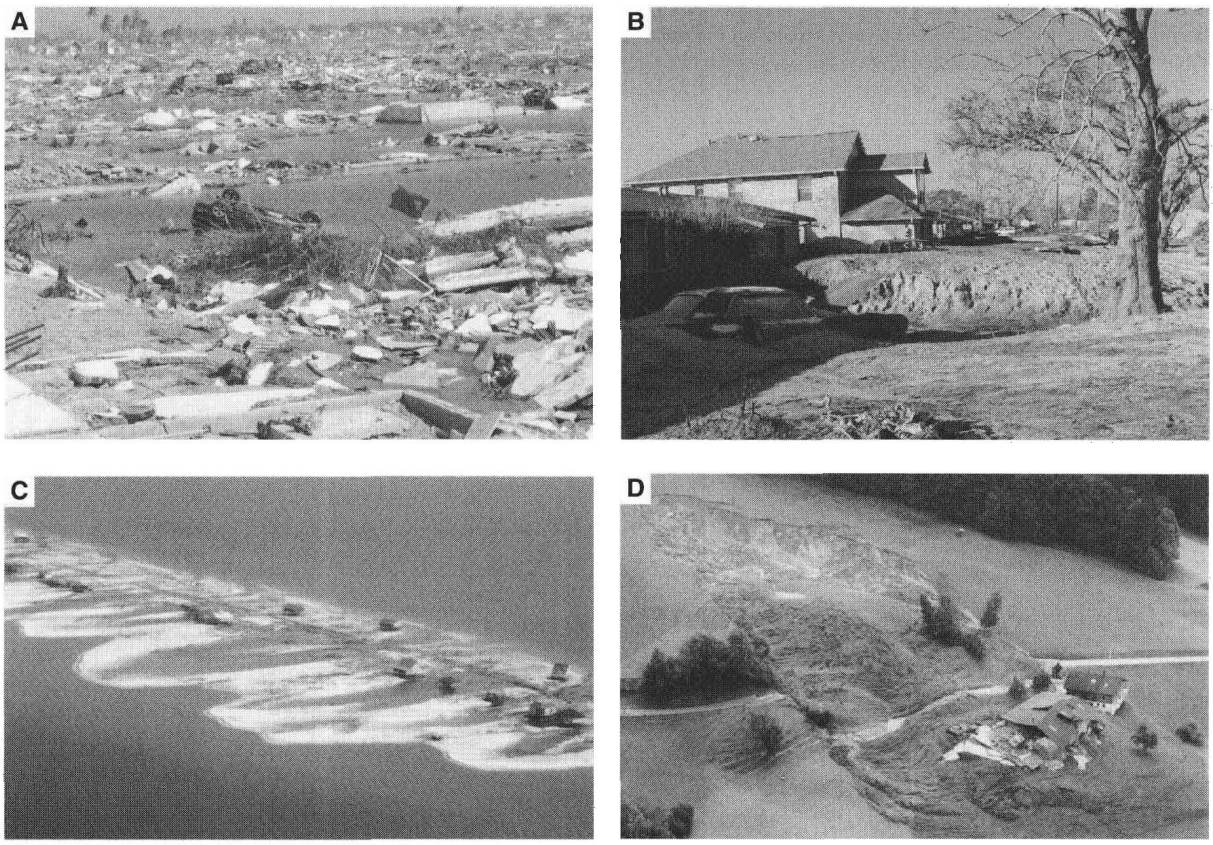

FIGURE 1.3. (A) Tsunami damage in Banda Aceh, Sumatra, 2004. Photo courtesy of Guy Gelfenbaum of the US Geological Survey (http://walrus.wr.usgs.gov/tsunami/sumatra05/). (B) Sand deposits in New Orleans associated with levee breaches during Hurricane Katrina in 2005. Photo courtesy of Suzanne Leclair. (C) Beach erosion, Dauphin Islands, Alabama, following Hurricane Katrina in 2005. Photo courtesy of Robert Young. (D) A slump and landslide, northern Austria. Photo courtesy of Henry Posamentier. (See Plate 3 for color versions.)