5

FORM, PROCESS AND MATERIALS

Approaches to a central concept of form, process and materials have focused on processes, landform evolution, and climatic geomorphology. Although these developed separately until the late 20th century a more holistic approach has recently brought them together, especially fostered by multidisciplinary research. It is now appreciated that advances in macroscale geomorphology have enabled large-scale landform developments to complement small-scale process research. Using covering law models of explanation, it is possible to recognize geographical, geophysical macro geomorphology, and historical approaches

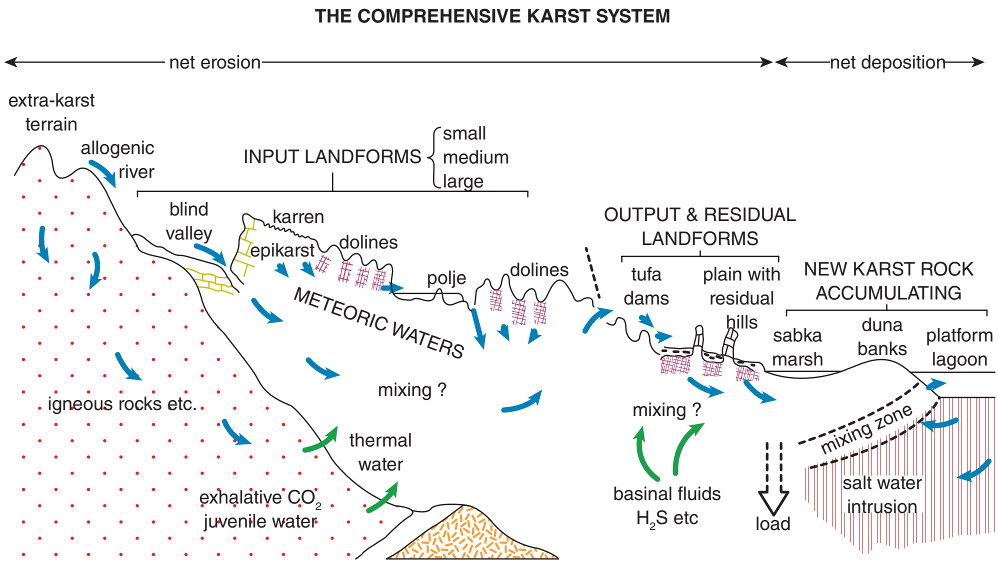

Figure 5.1 The comprehensive karst system (from Ford and Williams, 1989, 2011)

THE STRUCTURE OF INTEGRATED GEOMORPHOLOGICAL EXPLANATION

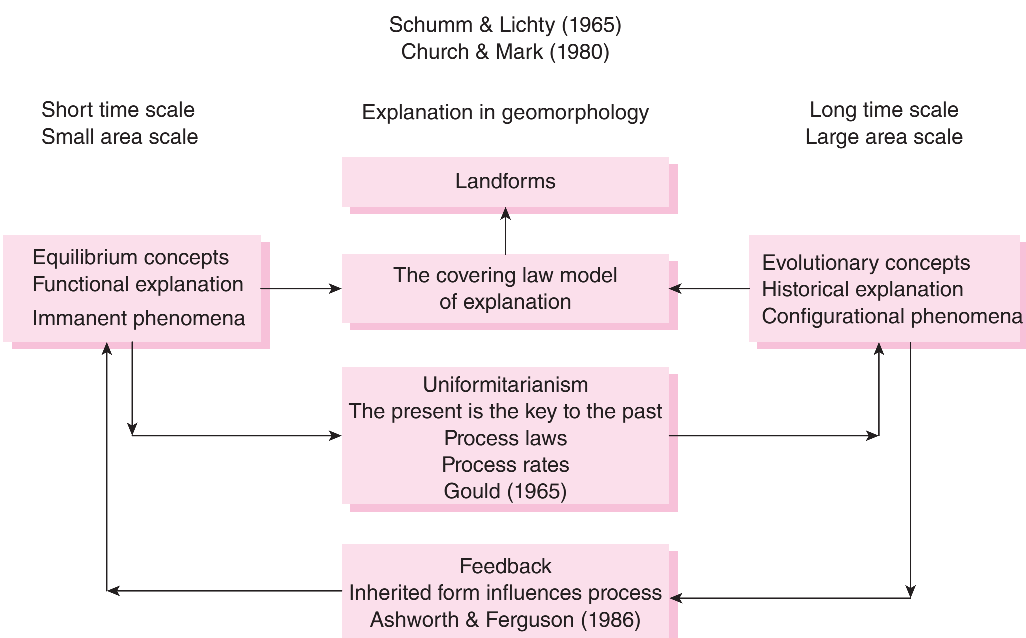

Figure 5.2 This summary diagram suggests that geomorphological explanations require both functional and historical elements. The former provides a general understanding of present process and the basis for reconstructing the past; the latter provides the specific initial conditions which contextualize this understanding (from Richards and Clifford, 2011)

Table 5.1 Some recent categorizations of approaches to geomorphology

Author	Types of Approach
Slaymaker (1997)	Suggests at least five different groups of geomorphologists in terms of research goals and methods: • Morphographers, who analyse static landform and material parameters • Historical-genetic geomorphologists, who analyse long-term development • Specialists in energy flow and material transfer close to the earth surface • Functional geomorphologists who analyse the dynamic interaction of energy with landforms and materials • Applied geomorphologists who interpret geomorphology to society and explore the influence of society on landforms
Summerfield (2005a)	Saw two scales of geomorphology: small scale process geomorphology contrasting with macroscale geomorphology reflecting advances made by researchers outside the traditional geomorphological community
Church (2005)	The study of landscape-forming processes, at both topographical and regional scales, forms the central theme of geomorphology: the focus must be on the physics underlying the processes, not upon the specifics of place and time; the concern with generic physics brings geomorphology into the scientific mainstream
Murray et al. (2009)	Geomorphologists today are employing a rapidly expanding, interdisciplinary set of tools that are revolutionizing how we understand Earth-surface processes. Historically qualitative, descriptive models dominated geomorphology. More recently, however, the discipline has turned the corner and is now accelerating along the leading edge of quantitative science. The wealth of data collected in the past, along with the development of an array of new quantitative techniques for characterizing landscapes and landscape change, has enabled a renaissance in theory and modelling; modern geomorphology is feeding off its observation-rich history.

(Continued)

Table 5.1 (Continued)

Author	Types of Approach
Church (2010)	Geomorphology is simultaneously developing in diverse directions: on the one hand it is becoming a more rigorous geophysical science, namely a significant part of a larger earth science discipline; on the other it is becoming more concerned with human social and economic values, with environmental change, conservation ethics, with the human impact on environment, and with issues of social justice and equity
Huggett (2011)	Geomorphologists study landforms in at least four ways: • First is a process–response (process–form) or functional approach that builds upon chemistry and physics, utilizes a systems methodology, and is referred to as surface process, or simply process, geomorphology • Second is the landform evolution approach that has its roots in historical geological science (geohistory), and is sometimes called historical geomorphology • Third is an approach that focuses on characterizing landforms and landform systems and that stems from geographical spatial science • Fourth is an environmentally sensitive approach to landforms, systems of landforms, and landscape at regional to global scales
Phillips (2011a)	Approaches to geomorphology tend to focus either on process mechanics and process–response relationships, or on histories and trajectories of landscape evolution. Process-based approaches lend themselves to a stimulus–response or disturbance–recovery perspective of geomorphic change. Historical approaches are more likely to be associated with a chronological, sequential view.

Table 5.2 Characteristics of rocks and superficial deposits relevant to form and process (developed from Gregory, 2010)

Features	Rock Characteristics	Influence on Landform
Lithology	Grain size and particle size, sorting, particle shape, fabric (orientation and packing) Physical and chemical composition	Arenaceous (largely sand), argillaceous (largely clay) and calcareous landforms, igneous and metamorphic landforms
Structure	Internal characteristics – joints, bedding planes	Detailed shape of slopes and landforms, tors
	Folding, faulting, dip, fractures	Faulted landforms, fault scarps, fault-line scarps, horst and graben, cuestas, dome structures
Water relationships	Porosity (proportion of voids in the rock, their size distribution, arrangement and degree of compaction); microporosity (proportion of pores <0.005mm). Water-related/ease of water absorption and transmission Permeability (measure of ability of water to pass through), reflecting pore spaces and joints, fissures etc. Water absorption (amount of water absorbed in unit time e.g. 24 hours) Saturation coefficient (measure of the amount of water absorbed in a unit of time expressed as a fraction of the pore space)	Frequency of fluvial landforms such as drainage density (length of stream channel divided by basin area), karst landforms
Overall characteristics	Rock mass strength measurement system of five categories based on intact strength rating, weathering, joint characteristics, groundwater (Selby, 1980; Moon, 1984)	Categories relate to angles of rock slopes

(Continued)

Table 5.2 (Continued)

Features	Rock Characteristics	Influence on Landform
Rock strength and resistance	Properties which relate to the strength (measured by compressive strength, tensile strength, shear strength). Can reflect engineering properties: tensile strength, Atterberg limits, compressive and shear strengths, particle size, infiltration capacity, erodibility, bulk density, consolidation, bearing capacity	Resistance to erosion, volcanic plugs
Hardness	Properties measuring the hardness (resistance to abrasion) or toughness of rocks (resistance to crushing or impact). Mohs' scale discriminates gypsum, muscovite (up to 2.5), apatite (5) and quartz (7).	Abrasion of rocks on beaches can give differential erosion
Rock colour	Reflects petrological content and effects of weathering	Gives colour to landforms and landscapes

RELEVANT ARTICLES IN *PROGRESS IN PHYSICAL GEOGRAPHY:*

Bonnaventure, P. P. and Lamoureux, S.F. (2013) The active layer: a conceptual review of monitoring, modelling techniques and changes in a warming climate, *Progress in Physical Geography,* 37: 352–76.

Church, M. (2010) The trajectory of geomorphology, *Progress in Physical Geography,* 34: 265–86.

Martin, Y.E. and Johnson, E.A. (2012) Biogeosciences survey: studying interactions of the biosphere with the lithosphere, hydrosphere and atmosphere, *Progress in Physical Geography,* 36: 833–52.

Summerfield, M.A. (1986) Tectonic geomorphology: macroscale perspectives, *Progress in Physical Geography,* 10: 227–38.

Twidale, C.R. and Lageat, Y. (1994) Climatic geomorphology: a critique, *Progress in Physical Geography, September,* 18: 319–34.

UPDATES

Analysis of links between form, process and materials is illustrated by a study of ice-marginal moraines often used to reconstruct the dimensions of former ice masses. A review paper shows that distribution of such moraines reflect a number of factors including topography as well as ice-marginal positions:

Barr, I.D. and Lovell, H. (2014) A review of topographic controls on moraine distribution, *Geomorphology*, 226: 44–64.

An interesting new paper explores methods for assessing how hillslopes would function without life, a topic of concern to planetary sciences in general:

Amundsen, R., Heimsath, A., Own, J., Kyunsoo, Y. and Dietrich, W.E. (2015) Hillslope soils and vegetation, *Geomorphology*, 234: 122–32.

A review of the invention and development of the idea of transport capacity in the fluvial, aeolian, coastal, hillslope, débris flow, and glacial process domains, explains why the original relation between the power of a flow and its ability to transport sediment can be challenged and suggests that new theories of sediment transport are needed to improve understanding and prediction and to guide measurement and management of all geomorphic systems: Wainwright, J., Parsons, A.J., Cooper, J.R., Orford, J.D. and Knight, P.G. (2015) The concept of transport capacity in geomorphology, *Reviews of Geophysics*, 53: 1155–202.

Bedrock strength, not easily documented, influences slope stability, landscape erosion, and fluvial incision but is often ignored or indirectly constrained in studies of landscape evolution. A large dataset of measured bedrock strength organized by rock units exposed along the length of the trunk of Green-Colorado River through the iconic Colorado Plateau of the western US reveals logical trends between tensile and compressive strength as well as between strength, rock type and age and conclude that equilibrium adjustment to bedrock strength, not differential uplift or transient incision, is the first-order control on large-scale fluvial geomorphology in the Colorado Plateau with broad implications for the interpretation of topography in terms of tectonic drivers: Bursztyn, N., Pederson, J.L., Tressler, C., Mackley, R.D. and Mitchell, K.J. (2015) Rock strength along a fluvial transect of the Colorado Plateau – quantifying a fundamental control on geomorphology, *Earth and Planetary Science Letters*, 429: 90–100.

An approach to Earth Surface System in terms of laws, place and history is offered as a pedagogical device which can be applied to many specific problems: Phillips, J.D. (2017) Laws, place, history and the interpretation of landforms, *Earth Surface Processes and Landforms*, 42: 347–54.