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Preface

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Preface

This book represents a very important and novel contribution that summarizes the current knowledge about badlands on a regional and global scale, and we are honoured to be given the opportunity by the editors to write the preface of this book on badlands.

A distant precursor of the work presented here is the milestone book by Rorke Bryan and Aaron Yair entitled '*Badland, Geomorphology and Piping*' that was published in 1982. Some of the issues that were addressed in their book reappeared here. However, the book presented here is based on recent progress made, and new findings done in the field of badland research, but which also has been put in the context of Global Change.

The ongoing research on badlands, as reported in this book, is dealt with from different points of view. As discussed in [Chapter 1](#), the number of studies of badlands has progressively increased throughout the 20th century and continued in the 21st century. This fact is corroborated by the numerous recent review studies published on badlands, the publication of special issues in scientific journals and monographs, and as well as, by the organization of scientific meetings focusing on badlands. There are many authors, all over the world (including the authors of the presented book), who have focused their research on different topics related to badlands such as the processes, geomorphology and origin of badlands. This includes studies into piping, hydrology, erosion rates, lithology and material properties, not only their surface cover, both in terms of physical and biological crusts, and vegetation cover, methods of study, modelling and advanced measurement methodologies, but also their restoration, conservation and importance for geoheritage and geotourism.

The term badlands refers to the fact that they constitute land unsuitable for agriculture or grazing. However, they form exceptional landscapes, which have led some of them to be declared a World Heritage Site by UNESCO. The importance of badlands may lie in the fact that they are landscapes that exist throughout the world and under different climates, although their presence is greater in semiarid areas.

On the other hand, many of the areas occupied by badlands cause significant erosion and subsequent (off-site) sedimentation problems. Badlands, made up of rills, gullies and piping, are important sources of sediment that silt up reservoirs, and this makes that their study is justified from different points of view.

This exciting book, structured in nine chapters, has brought together magnificent reviews of different studies on badlands in seven chapters, as well as two complete case studies. The following is a brief summary of the different aspects discussed in the successive chapters.

[Chapter 1](#) '*Perspectives on badland studies in the context of global change*', whose authors are Juan Francisco Martínez-Murillo and Estela Nadal-Romero, introduces us to the topic, showing us firstly an overview of badlands throughout the world, and then giving an overview of recent research and a brief background on current studies of badlands, grouped by theme, also indicating the objectives pursued,

and current knowledge. A very interesting aspect of this chapter is that it deals with the research questions in the context of Global Change: Why is the study of badlands relevant? What can we do to limit the sediment yield from badlands? Should badlands be reclaimed or protected? Or what is the fate of badlands in the context of Global Change? Some of the questions that Martínez-Murillo and Estela Nadal-Romero raise are answered in the following chapters.

In **Chapter 2**, Mariano Moreno-de las Heras and Francesc Gallart address '*The origin of badlands*'. Despite numerous existing studies of badlands, few have focused on their origins. The authors conclude that the development of badlands is modulated by the association of four critical terrain instability factors: (1) vigour of relief, (2) a rapidly weatherable soft lithology transforming into an erodible regolith, (3) an erosive climate with marked rainfall or snowmelt events and (4) additional disturbances or environmental constraints that determine the presence and development of a protective vegetation cover (e.g., high-frequency wet–dry cycles, intense freezing, bedrock salinity or human degradation). They also point out that the combined action of these four factors is necessary for badland initiation. All these four critical terrain factors may directly or indirectly change over time, leading to the initiation, stabilization or rejuvenation of badland systems.

Chapter 3 also deals with a topic of great interest. '*The role of lithology: parent material controls to badland development*'. Milica Kašanin-Grubin, Francesca Vergari, Francesco Troiani and Marta Della Seta consider that fundamental attention should be given to badland materials, which main features are grain size, clay mineralogy and physicochemical properties. Although the first studies on badlands focused on erosive processes, more recent research analyses the parent material properties, considering that these have a bigger role in understanding badland initiation and evolution. This chapter discusses in detail the main badland material characteristics and the main studies focused on badland lithological properties (physical and chemical). It is also analyzed the influence of climate on material behaviour, weathering profiles and soil stabilization and the effect of material properties to badland slope denudation processes (rill and gully development, piping initiation, *calanchi* and *biancane* and landsliding). The authors conclude that the properties of badland materials play a key role in different geomorphic processes and the related development of badland landforms.

Chapter 4 is a case study '*Badlands and the dynamics of human history, land use, and vegetation through centuries*' whose authors are Dino Torri, Mauro Rossi, Francesco Brogi, Michela Marignani, Giovanni Bacaro, Elisa Santi, Enrico Tordoni E., Valerio Amici V. and Simona Maccherini. These authors carry out an interesting historical study to determine when the badlands emerged. They were also able to determine the average rate of denudation, which was estimated at 2 cm yr^{-1} , which allows them to estimate the age of badlands. They indicate how anthropogenic action is the main cause of the development of these badlands. The results of this study make them conclude that a real and wide multidisciplinary approach can actually bring together very detailed scenarios, which clarify links between causes and effects, including the impact of socioeconomic drivers.

'*Runoff generation in Badlands*' is the title of [Chapter 5](#), written by Yolanda Cantón, Emilio Rodriguez-Caballero, Sonia Chamizo, Caroline Le-Bouteiller, Albert Solé and Adolfo Calvo. In this chapter, the following important aspects are dealt with from a global perspective: (1) Field observations of runoff rates at different scales under contrasting climate and lithological conditions; (2) mechanisms of runoff generation; (3) time- and scale-dependent drivers (plot, hillslope and catchment), and revisiting the responses of badlands to rainfall: infiltration excess overland flow; partial area infiltration excess and finally saturation; (4) Global Change impacts on badlands runoff and (5) research gaps and future research. We would like to highlight the last section on research gaps that still exist and where future research should go.

In [Chapter 6](#), Hazel Faulkner, with extensive experience in the study of piping processes, deals with '*The role of piping in the development of badlands*'. Piping processes have not always been considered in the studies of badlands, so we would like to highlight a final sentence from the Faulkner's chapter: 'if you are working in badlands in marine-sourced marl or mudrock lithologies, look for pipes. Because you are unlikely to see their full extent on first inspection it does not mean they are not there, or that they were not part of the story in the past, nor (if undercut or managed) that they will not be part of the story in the future'. She discusses in detail the processes and conditions under which piping occurs, such as the presence of dispersive materials and hydrological constraints. In this chapter, the small-, medium- and large-scale morphological characteristics found in piping-prone materials are described as well, and another aspect of great interest dealt with, the discussion of the possible options for remediation of piping in piping-prone materials.

Estela Nadal-Romero and José María García-Ruiz in [Chapter 7](#) '*Rethinking the spatial and temporal variability of erosion in badlands*' wrote another very interesting synthesizing chapter. The well-judged study examines different aspects of badlands, such as measurement methodology, factors affecting erosion in badlands and spatial and temporal variability of erosion processes in dry and humid badlands, and the complex spatial and temporal connections at the catchment scale. Of special interest are the sections 'Sediment yield and connectivity in experimental badlands catchments', 'How can we limit sediment yield from badlands?' and 'Badland erosion and Global Change'. They conclude by indicating, on the one hand, that some badlands merit special consideration as extreme landforms that must be preserved as geomorphological monuments of exceptional value, and on the other hand, that more studies should be developed on efficient techniques for controlling small badlands, particularly for badlands that threaten agricultural areas, residential areas, and infrastructure.

Juliane Krenz and Nikolaus J. Kuhn are the authors of [Chapter 8](#) entitled '*Assessing badland sediment sources using UAVs*'. The aims of this study are to investigate the use of UAVs for generating high-resolution DTMs of badland features. The study was conducted in a catchment in the Karoo rangelands and included an assessment of the badland erosion as sediment source contributing to the siltation of a small reservoir at the lower end of the studied catchment. A comparison of available low-resolution cartographic data of the catchment and the high-resolution

unmanned aerial vehicle (UAV)–based DTM generated for this study, in combination with field visits, was used to assess the contribution of UAVs to badland erosion studies. They showed that UAV imagery is suitable for identifying, mapping and quantifying badlands. However, it should be noted that the methodology is only as good as the underlying georeferencing. As UAV technologies and capabilities are constantly improving, UAV-based badland mapping is becoming a valuable tool and offers a high flexibility regarding spatial and temporal resolution, in particular for producing high-resolution images in remote areas. There is potentially a wide range of UAV-derived data products for research and land management requiring information on badland morphologies and dynamics.

Finally, [Chapter 9](#), in which 10 authors participated (Wojciech Zglobicki, Jean Poesen, Michael Daniels, Maurizio Del Monte, Antonio Jose Teixeira Guerra, Veena Joshi, Garry Paterson, Jeff Shellberg, Albert Solé-Benet and Zheng'an Su), focusses on '*Geotouristic value of badlands*'. In this interesting chapter, carried out at world level, the badlands are approached from a different perspective, taking into account their aesthetic, biological, ecological, cultural or scientific values. The objective of this chapter is to investigate the geotouristic value of badlands from around the world. It also addresses the following questions: (1) What is the role of badlands as tourist destinations? (2) Why do tourists visit badlands? (3) Are badlands threatened by human activities? The countries analyzed have been: Australia, Belgium, Brazil, China, India, Italy, Poland, South Africa, Spain, the United States and Canada. The results of the study show that badlands do not receive a lot of attention by geotourists unless they possess natural or scientific values that is unique on a global scale, and where accessibility (distance and/or terrain) is not a problem. A few badlands are located within UNESCO World Heritage Sites and UNESCO Global Geoparks. Such sites are important destinations for tourists who may become geotourists by using prepared geoproducts. The establishment of new geoparks encompassing badlands is the best strategy for geotourism development in these areas.

As you will have seen from the forgoing, this work is an important contribution to the study of badlands. It highlights the current status of badland research and also proposes lines of future research; not only in regards to a better understanding of these landscapes and their processes but also within the context of Global Change.

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