Landforms of the Earth

Francisco Gutiérrez • Mateo Gutiérrez

Landforms of the Earth

An Illustrated Guide

Francisco Gutiérrez
Earth Sciences Department
University of Zaragoza
Zaragoza, Spain

Mateo Gutiérrez
Earth Sciences Department
University of Zaragoza
Zaragoza, Spain

ISBN 978-3-319-26945-0 ISBN 978-3-319-26947-4 (eBook)
DOI 10.1007/978-3-319-26947-4

Library of Congress Control Number: 2016930684

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Nieves, Marina, Isabel and Francho

Preface

This book has been produced by two university lecturers with long experience in teaching geomorphology and other related subjects. Students enrolled in courses dealing with earth-surface processes and landforms (geomorphology, physical geography, geology, geohazards, environmental sciences) have access to excellent geomorphology textbooks with superb descriptions. However, only some of the landforms explained in those publications are illustrated with images. This hinders the comprehension of explanations on the landforms and genetic processes and the students' capability to correctly diagnose geomorphic features, both in the field and using remote-sensed data. We feel that visualization of landforms is essential for learning geomorphology and stimulating the interest on this field-based subject; a picture is worth a thousand words.

Nowadays, researchers dealing with geomorphological issues are overwhelmed by an enormous variety of rapidly evolving techniques. Some of them, like dating methods, remote-sensing, or geographical information systems, have greatly contributed to the recent renewed interest in geomorphology. However, the means should not set aside the aims. Basic knowledge is essential to conduct compelling geomorphological investigations, regardless of the sophistication of the methods used. We may use the best available remote-sensed data, but we only see what we know. Remote-sensed data may provide a great deal of information on the landforms, but we should feel forced to examine them directly in the field. The new techniques can complement the classical field-based approaches, but cannot replace most of them.

We hope this photographic guide will constitute an useful educational resource for students, researchers, and practitioners. It may also satisfy the curiosity of people keen on nature, travellers and landscape photographers, who want to learn about the names and origin of the landforms they encounter in their trips. Commonly, stunning geomorphological features constitute the main highlight of protected areas (National Parks, UNESCO World Heritage Sites) and outstanding tourist attractions.

The book illustrates with more than 360 photographs and satellite images from all over the world the main landforms of the Earth's continental surface. The good quality colour images have been thoroughly selected, showing representative and dramatic examples. Each landform or group of geomorphic features is described with concise, direct, and easy-to-read texts. The structure of the book follows classical subdivisions of geomorphology, with five chapters dealing with structural geomorphology (structural, tectonic, volcanic, karst, and granite landforms), four devoted to azonal geomorphic systems and processes (weathering, slope movements, fluvial, and coastal landforms), and three chapters covering the three main morphoclimatic environments (glacial, periglacial, and desert-aeolian landforms). Readers can easily find more lengthy and in-depth explanations in the general and specific geomorphology textbooks recommended at the end of the book.

Zaragoza, Spain

Francisco Gutiérrez
Mateo Gutiérrez

Acknowledgements

We, the authors, are very grateful to the colleagues who have reviewed the different sections of the book providing insightful comments: Anthony Cooper and Kenneth Johnson (introductions), Clifford Ollier (structural and weathering landforms), James McCalpin (tectonic landforms), Juan Carlos Carracedo (volcanic landforms), Ira Sasowsky (karst landforms), Piotr Migoń (granite landforms), Mauro Soldati (slope movements), Adrian Harvey (fluvial landforms), Alan Trenhaile (coastal landforms), Xavier Mir (glacial landforms), Gonçalo Vieira (periglacial landforms), and Andrew Goudie (desert and aeolian landforms).

We would also like to thank those who have kindly given permission to reproduce their images: Franck Audemard, Philippe Audra, Javier Baztán, Nicolas Benoist, Jean-Yves Bigot, Janina Borysiak, Ferrán Cardona, Juan Carlos Carracedo, Rosa Carrasco, Márcio Décio, Damien Closson, Anthony Cooper, Donald Crain, Beth van Dusen, Germán Flor, José María García-Ruiz, Ángel Ginés, Juan Carlos Gordillo, Paula James, Cezary Kabała, Alfredo Lainez, Tim Lawnicki, James McCalpin, Vincent Matthews, Tony Merino, Piotr Migoń, Xavi Mir, John Mylorie, Mohammad Hasan Nazari, José Ortega, Arthur Palmer, Arturo Polo-Ena, Tom Rayner, Carles Roqué, Ira Sasowsky, Matti Seppala, Servicio de Cartografía del Principado de Asturias, Shahram Sherkati, Keith Smith, Scott Weathersson, Javier Ventosa, Virtualgeo, Jon White, Paul Williams, and Zbigniew Zwoliński.

Contents

1	Introduction	1
2	Structural Landforms	3
2.1	Mesa and Butte.....	3
2.2	Cuesta and Hogback.....	6
2.3	Chevron and Flatiron.....	7
2.4	Ridge and Rock Wall.....	7
2.5	Monoclinical Scarp	9
2.6	Anticlinal Ridge	9
2.7	Perched Syncline.....	13
2.8	Conglomerate Pinnacle	13
2.9	Alcove	15
2.10	Salt Dome and Namakier	15
3	Tectonic Landforms.....	21
3.1	Fault Scarp	21
3.2	Fault Facet.....	22
3.3	Tectonic Fissure	24
3.4	Defeated and Beheaded Drainage	26
3.5	Deflected Drainage.....	28
3.6	Landforms of Strike-Slip Faults.....	28
3.7	Flexural-Slip Fault Scarp	32
4	Volcanic Landforms	35
4.1	Volcano.....	36
4.2	Cone	38
4.3	Maar	40
4.4	Lava Dome	41
4.5	Lava Flow and Associated Features	42
4.6	Lava Tube.....	42
4.7	Caldera	48
4.8	Flank Collapse.....	50
4.9	Volcanic Neck	50
4.10	Volcanic Hydrothermal Manifestations.....	50
5	Karst Landforms	59
5.1	Polje.....	60
5.2	Solution Sinkhole.....	60
5.3	Collapse Sinkhole.....	60
5.4	Cover Suffosion Sinkhole	63
5.5	Sagging Sinkhole	63
5.6	Evaporite Collapse Valley	65
5.7	Tower Karst.....	65

5.8	Corrosion Plain.....	65
5.9	Fluviokarstic Canyon	67
5.10	Blind Valley.....	68
5.11	Pocket Valley.....	68
5.12	Karrenfield.....	68
5.13	Circular Karren.....	69
5.14	Linear Karren (Hydraulically Controlled)	74
5.15	Structural Karren.....	74
5.16	Phreatic Cave	75
5.17	Vadose Cave	75
5.18	Hypogenic Cave.....	76
5.19	Flank-Margin Cave	78
5.20	Pool Speleothems.....	78
5.21	Dripstones	81
5.22	Flowstones.....	82
5.23	Speleothems Formed by Capillary Water.....	82
5.24	Speleothems Formed by Evaporation	85
5.25	Collapse Breccia and Debris Cone.....	85
5.26	Solution Notch	86
5.27	Scallop.....	87
5.28	Tufa Deposits	87
5.29	Travertine Deposits	88
6	Granite Landforms	103
6.1	Inselberg.....	103
6.2	Bornhardt.....	104
6.3	Tor and Nubbin	104
6.4	Corestone and Granite Boulder.....	104
7	Weathering Landforms.....	111
7.1	Tafoni and Alveoli.....	112
7.2	Gnamma.....	112
7.3	Flared Slope	113
7.4	Spalling and Flaking	113
7.5	Spheroidal Weathering	120
7.6	Frost Shattering	120
7.7	Sheeting.....	122
7.8	Defile.....	122
7.9	Gypsum Tumuli.....	125
8	Slope Movements.....	127
8.1	Translational Slide.....	127
8.2	Rotational Slide.....	128
8.3	Lateral Spread	128
8.4	Flow.....	128
8.5	Topple.....	129
8.6	Fall.....	130
8.7	Rock Avalanche.....	132
8.8	Sackung.....	132
8.9	Solifluction	133
9	Fluvial Landforms.....	155
9.1	Bedrock Channel.....	156
9.2	Knickpoint, Waterfall	156
9.3	Alluvial Channel	156

9.4	Ephemeral Channel	158
9.5	Terrace	158
9.6	Alluvial Fan	160
9.7	Mantled Pediment	164
9.8	Rill	165
9.9	Gully	165
9.10	Piping	173
9.11	Armoured Mud Ball	175
10	Coastal Landforms	177
10.1	Coastal Cliff	178
10.2	Shore Platform	178
10.3	Marine Terrace	178
10.4	Beach	179
10.5	Spit and Barrier	180
10.6	Lagoon	180
10.7	Tombolo	181
10.8	Estuary	181
10.9	Ria	183
10.10	Delta	183
10.11	Coral Reef	184
11	Glacial Landforms	199
11.1	Glacier	200
11.2	Cirque	200
11.3	Glacial Valley and Fjord	201
11.4	Roche Moutonnée	202
11.5	Moraine	203
11.6	Drumlin	205
11.7	Esker	206
11.8	Outwash Plain	207
12	Periglacial Landforms	221
12.1	Talus Slope and Talus Cone	221
12.2	Block Field, Block Slope and Block Stream	222
12.3	Grèzes Litée	223
12.4	Nivation Hollow and Protalus Rampart	224
12.5	Rock Glacier	225
12.6	Patterned Ground	230
12.7	Pingo	233
12.8	Palsa	233
12.9	Alas	233
13	Desert and Aeolian Landforms	237
13.1	Playa Lake	238
13.2	Desiccation Cracks	238
13.3	Salt Polygons	241
13.4	Desert Varnish	241
13.5	Calcrete	241
13.6	Talus Flatirons and Relict Slope Rings	242
13.7	Pediment	242
13.8	Desert Pavement	243
13.9	Ventifact	244
13.10	Yardang	244
13.11	Pan and Lunette	244

13.12	Barkhan Dune.....	245
13.13	Transverse Dune.....	252
13.14	Parabolic Dune	252
13.15	Longitudinal Dune	252
13.16	Star Dune.....	254
13.17	Climbing Dune	254
13.18	Nebkha Dune.....	254
13.19	Blowout.....	258
Further Reading.....		261
Index.....		263