## LANDFORMS AND GEOLOGY OF GRANITE TERRAINS

C.R. Twidale University of Adelaide, Australia

J.R. Vidal Romaní University of Coruña, Spain



Library of Congress Cataloging-in-Publication Data Applied for

Cover Illustrations

Front: Acuminate and ensiform residual, Mt. Manypeaks area, near Albany, Australia. Photograph by C.R. Twidale.

Back: Domed granite inselberg from the Bolson of the Señor de la Peña Valley, Anillaco, República Argentina. Photograph by J.R. Vidal Romaní.

Copyright © 2005 Taylor & Francis Group plc, London, UK

All rights reserved. No part of this publication or the information contained herein may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the publisher.

Although all care is taken to ensure the integrity and quality of this publication and the information herein, no responsibility is assumed by the publishers nor the author for any damage to property or persons as a result of operation or use of this publication and/or the information contained herein.

Published by: A.A. Balkema Publishers Leiden, The Netherlands, a member of Taylor & Francis Group plc www.balkema.nl and www.tandf.co.uk

ISBN 04 1536 435 3

Printed in Great Britain

## Table of Contents

Preface and acknowledgements				
1	Characteristics and foundations			
	1.1 Typical landforms and landscapes	1		
	1.2 Previous work	5		
	1.3 Occurrences of granite	9		
	1.4 Granite – definition and composition	10		
	1.5 Physical characteristics	13		
	1.6 Orthogonal fracture systems	16		
	1.7 Fractures and drainage patterns	18		
2	Sheet fractures and structures	27		
	2.1 Terminology	27		
	2.2 Description and characteristics	28		
	2.3 Theories of origin	32		
	2.3.1 Exogenetic explanations	33		
	2.3.2 Endogenetic explanations	41		
	2.4 Summary	47		
3	Weathering			
	3.1 Definition and significance	49		
	3.2 Physical disintegration	49		
	3.3 Chemical alteration	54		
	3.4 The course of weathering in granite	54		
	3.5 Controls of weathering	58		
4	Plains – the expected granite form			
	4.1 Weathering and surfaces of low relief	63		
	4.2 Plains of epigene (subaerial) origin	63		
	4.2.1 Rolling or undulating plains	64		
	4.2.2 Pediments	66		
	4.2.3 Relationship between pediment and peneplain	72		
	4.3 Etch plains in granite	72		
	4.4 Very flat plains	74		
	4.5 Multicyclic and stepped assemblages	75		
	4.6 Exhumed plains	78		
	4.7 Summary	79		
5	Boulders as examples of two-stage forms			
	5.1 The two-stage or etching mechanism	<b>81</b> 81		
	5.2 Boulders – morphology and occurrences	83		
	5.3 Subsurface exploitation of orthogonal fracture systems	83		
	5.4 Tectonic and structural forms	95		
	5.5 Types of peripheral or marginal weathering	97		

## VI Table of Contents

	5	5.6 Causes of peripheral weathering						
	5	5.7 Evacuation of grus	98					
	5	.8 Boulders of epigene origin	102					
	5	.9 Summary	103 105					
	6 I	Inselbergs and bornhardts						
	6	.1 Definitions and terminology	<b>109</b> 109					
	0	2 Bornhardt characteristics	115					
	0.	3 Theories of origin	113					
		6.3.1 Environment	118					
		6.3.2 The scarp retreat hypothesis	120					
		6.3.3 Tectonics and structure: faulting and lithology	120					
		0.3.4 Variations in fracture density	121					
		6.3.5 Differential subsurface weathering and the	127					
	6.	two-stage concept	127					
	0.	4 Evidence and argument concerning origins of bornhardts	131					
			101					
		6.4.1 Contrasts in weathering between hill and plain	131					
		0.4.2 incipient domes	131					
		6.4.3 Subsurface initiation of minor forms	131					
		6.4.4 Flared slopes and stepped inselbergs	132					
		6.4.5 Regional and local patterns in plan 6.4.6 Coexistence of forms associated with	139					
		6.4.6 Coexistence of forms associated with compression/shearing						
		6.4.7 Topographic settings	140					
		6.4.8 Occurrence in multicyclic landscapes	140					
		6.4.9 Fracture-defined margins	140					
		6.4.10 Age of inselbergs and bornhardts	142					
	6.5		142					
	6.6	Antiquity and inselberg landscapes	146					
	6.7	Summary	149					
			149					
7	Otl	her granitic residuals and uplands						
	7.1	Isolated residuals	153					
		7.1.1 Nubbins	153					
		7.1.2 Castle koppies	153					
		7.1.3 Large conical forms or medas	155					
		7.1.4 Towers and acuminate forms	159					
	7.2	Massifs	162					
	7.3	Regions of all slopes topography	163					
	7.4	Discussion	169					
			171					
8	Minor forms developed on steep slopes							
	8.1	Flared slopes	<b>173</b> 173					
		8.1.1 Description and characteristics						
		8.1.2 Origin	173 177					
	0 2	8.1.3 Changes after exposure	183					
	8.2	Fretted basal slopes and other variants	183					
	8.3 8.4	Scarp-foot weathering and erosion, and the piedmont angle	184					
	0.4	Rock platforms	190					
		8.4.1 Description	190					
		8.4.2 Origin	190					

	8.5	Scarp-foot depressions 8.5.1 Description	190 190
		8.5.2 Origin	192
	8.6	Flutings or grooves	193
		8.6.1 Description	193
		8.6.2 Origin	196
		8.6.3 Surface or subsurface initiation?	200
		8.6.4 Inversion	203
9	Min	207	
	9.1	Rock basins	207
		9.1.1 Description	207
		9.1.2 Nomenclature	211
		9.1.3 Origin	211
		9.1.4 Differentiation of major types	216
		9.1.5 Evacuation of debris	219
	0.0	9.1.6 Rate of development	219 220
	9.2	Plinths and associated blocks and boulders	
		9.2.1 Description	220 221
	0.2	9.2.2 Origin	221
	9.3	Pedestal rocks 9.3.1 Terminology	222
			222
	9.4	9.3.2 Origin Gutters or runnels	222
	9.4	9.4.1 Terminology	224
		9.4.1 Description	224
		9.4.2 Description 9.4.3 Origin	224
	9.5	Rock levees	228
	9.5 9.6	Rock doughnuts	220
	9.0	9.6.1 Description	230
		9.6.2 Origin	230
		9.6.3 Evidence and argument	232
	9.7	Fonts	232
	9.1	10113	232
10		res and tafoni	235
	10.1		235
		2. Caves associated with corestones and grus	235
	10.3		236
	10.4		238
		10.4.1 Description	238
		10.4.2 Process	245
		10.4.3 Stages of development	249
		10.4.4 Case-hardening and other veneers	250
	10.5	5 Speleothems	251
11	Spli	it and cracked blocks and slabs	259
	11.1		259
		11.1.1 Description	259
		11.1.2 Origin	260
	11.2		264
	11.3		266
		11.3.1 A-tents	266

		11.3.2	Overlapping slabs		0.51	
		11.3.3	Displaced slabs		271	
		11.3.4	Chaos		271	
		11.3.5	Wedges		275	
		11.3.6	Origin of the forms		276	
		11.3.7	Relationship of A-tents and pressure ridges		278	
	11.4		282			
		11.4.1			282	
		11.4.2	Previous interpretations		282	
		11.4.3	Evidence		285	
		11.4.4	Explanations		287	
	11.5	Tesselat	ted pavements		287	
					291	
12	Zonality, azonality and the coastal context				202	
	12.1	Introduc	ction		<b>293</b>	
	12.2	Litholog	gical zonality and azonality		293	
	12.3	Climatic	c zonality and azonality		293	
	12.4	The coa	stal context		309	
					313	
13	Retrospect and prospect					
					327	
	Autho	r index			331	
	Locati					
			335			
	Subjec		343			
	About the authors					
					352	