

"When graduate students or postdocs ask what to read to improve their background in fault mechanics, Chris Scholz's book has always been at the top of my list. This much awaited third edition has been thoroughly updated with the latest findings and insights, from as recent as 2018, and will continue to be an important resource for all geophysicists and geologists interested in active faults."

Professor Roland Bürgmann, University of California, Berkeley

"On first publication in 1990, *The Mechanics of Earthquakes and Faulting* immediately became 'The Book' on the topic. This major revision presents all the new findings from the last fifteen years, including episodic tremor and slip phenomena, the complexity of seismic rupture processes, the mechanics of megathrust faults and associated tsunamis, and lubrication of faults. With its state-of-the-art content and rich bibliography of more than 2,000 references, this third edition is a must-read for everyone interested in earthquakes and faults – from undergraduate to the senior research level."

Professor Giulio Di Toro, Padua University, Italy

This essential reference for graduate students and researchers provides a unified treatment of earthquakes and faulting as two aspects of brittle tectonics at different timescales. The intimate connection between the two is manifested in their scaling laws and populations, which both evolve from fracture growth and interactions between fractures, whether dynamic or quasi-static. The connection between faults and the type of seismicity they generate is governed by the rate- and state-dependent friction laws – producing distinctive seismic styles of faulting. These friction laws also provide explanations for the gamut of earthquake phenomena: aftershocks, afterslip, earthquake triggering, and slow slip events.

The third edition of this classic treatise presents a wealth of new topics, as well as new observations from techniques such as CGPS and InSAR. These include slow earthquake phenomena; friction of phyllosilicates and at high sliding velocities; new observations of fault structures and segmentation; relative roles of strong and seismogenic versus weak and creeping faults in the continental and oceanic lithosphere; dynamic triggering of earthquakes; oceanic earthquakes; new observations of megathrust earthquakes in subduction zones; new results for deep earthquakes; and new observations of earthquake precursory phenomena.

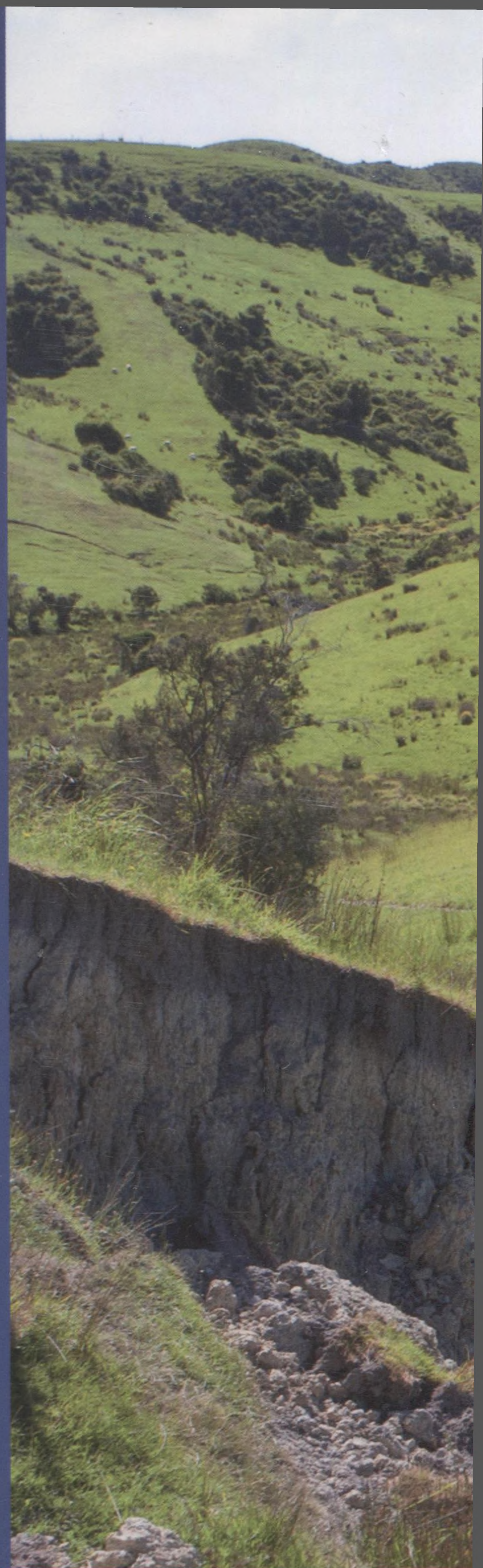


Online Resources
www.cambridge.org/scholz3ed

▶ All figures from the book, for instructor use

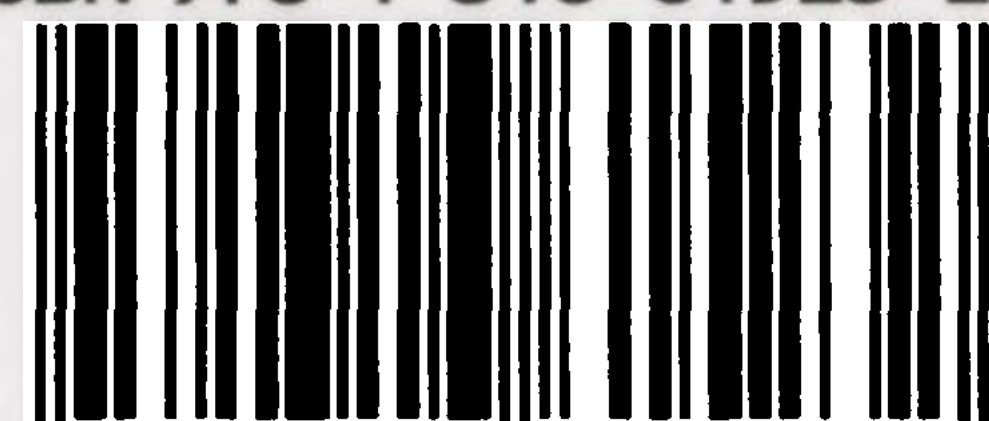
Cover illustration: the "Woodchester Wall" - a rupture scarp on the Kekerengu Fault in New Zealand, formed during the 7.8 magnitude Kaikoura earthquake in 2016. Photograph courtesy of Dr. Kate Pedley, University of Canterbury.

Cover design: Andrew Ward



CAMBRIDGE
UNIVERSITY PRESS
www.cambridge.org

ISBN 978-1-316-61523-2



9 781316 615232 >



Preface to the first edition	<i>page xi</i>
Preface to the second edition	xv
Preface to the third edition	xvii
List of symbols	xix
1 Brittle fracture of rock	1
1.1 Theoretical concepts	1
1.1.1 Historical	1
1.1.2 Griffith theory	3
1.1.3 Fracture mechanics	7
1.1.4 Crack models	12
1.1.5 Macroscopic fracture criteria	14
1.1.6 Laws of effective stress	17
1.2 Failure processes in rock	18
1.2.1 Tensile failure of rock	19
1.2.2 Shear failure in compression	22
1.2.3 Effect of scale on strength	29
1.2.4 Time dependence of strength of brittle rock	30
1.3 The brittle–plastic transition	35
1.3.1 General principles	36
1.3.2 The transition induced by pressure	37
1.3.3 The transition induced by temperature	38
1.3.4 Extrapolation to geological conditions	41

2	Rock friction	43
2.1	Theoretical concepts	43
2.1.1	Historical	43
2.1.2	The adhesion theory of friction	44
2.1.3	Elastic contact theory of friction	46
2.1.4	Other frictional interactions	50
2.2	Experimental observations of rock friction	53
2.2.1	Friction of bulk-structure rocks and minerals	53
2.2.2	Friction of lamellar minerals	53
2.2.3	Effects of ambient temperature, pressure, and pore pressure on friction	57
2.2.4	Wear	61
2.2.5	Friction at high sliding velocities	64
2.3	The stability of friction: stick-slip and stable sliding	71
2.3.1	Introduction	71
2.3.2	Rate effects on friction: the rate and state variable friction laws	74
2.3.3	Frictional stability regimes	80
2.3.4	Frictional stability properties of rocks and minerals	83
2.3.5	Dynamics of stick-slip	89
2.4	The friction–plastic transition	91
2.5	Friction under geological conditions	94
3	Mechanics of faulting	97
3.1	Mechanical framework	97
3.1.1	Anderson’s theory of faulting	97
3.1.2	Hubbert–Rubey theory of overthrust faulting	100
3.1.3	Fault rotation, reactivation, and friction	102
3.2	The formation and growth of faults	105
3.2.1	The problem of fault formation	105
3.2.2	Fault formation and growth	106
3.2.3	Fault interactions	117
3.2.4	Fault populations	123
3.3	Fault rocks, structures, and their evolution	127
3.3.1	Brittle fault structures	127
3.3.2	Ductile fault rocks and structures	137
3.4	Strength and rheology of faults	147
3.4.1	A synoptic shear zone model	148
3.4.2	Fault strength and stability	151
3.5	Fault morphology and mechanical effects of heterogeneity	159
3.5.1	Fault segmentation and maturity	159
3.5.2	Effect of fault segmentation on earthquakes	161

4	Mechanics of earthquakes	166
4.1	Historical development	166
4.2	Earthquake physics	168
4.2.1	The dynamic energy balance	168
4.2.2	Dynamic rupture propagation	171
4.3	Earthquake phenomenology	175
4.3.1	Earthquake scaling relations	175
4.3.2	Earthquake size distributions	183
4.3.3	Quantifying heterogeneity: the fractal nature of earthquakes	188
4.4	Observations of earthquakes	188
4.4.1	Case studies of continental earthquakes	188
4.4.2	Earthquake sequences	197
4.5	Earthquake interactions	200
4.5.1	Static triggering: Coulomb stress loading	201
4.5.2	Mechanisms for the time delay	204
4.5.3	Dynamic triggering	210
4.6	Slow earthquake phenomena	214
4.6.1	Quasi-periodic slow slip events and tremor in subduction zones	214
4.6.2	Other slow slip events and tremor	221
4.6.3	Mechanics of slow slip events	224
5	The seismic cycle	228
5.1	Historical	228
5.2	The crustal deformation cycle	230
5.2.1	Geodetic observations of strain accumulation	231
5.2.2	Models of strain accumulation	238
5.2.3	Postseismic phenomena	241
5.3	The earthquake cycle	248
5.3.1	Earthquake recurrence	248
5.3.2	Paleoseismology: geological observations of recurrence times	255
5.4	Segmentation and cycles: concepts and models	263
5.4.1	Fault segmentation and rupture barriers	264
5.4.2	Variations on cycles	269
5.5	Earthquake recurrence models	274
6	Seismotectonics	278
6.1	Introduction	278
6.2	Seismotectonic analysis	280
6.2.1	Qualitative analysis	280
6.2.2	Quantitative analysis	282
6.3	Subduction zone earthquakes	286
6.3.1	Case studies of megathrust earthquakes	286

6.3.2	Tsunami earthquakes	296
6.3.3	Seismogenic properties of subduction zones	298
6.3.4	Seismic coupling of subduction zones	303
6.4	Oceanic earthquakes	307
6.4.1	Mid-ocean ridge seismicity	309
6.4.2	Oceanic transform fault seismicity	312
6.4.3	Oceanic intraplate earthquakes	318
6.5	The mechanism of deep earthquakes	321
6.5.1	Intermediate-focus earthquakes	322
6.5.2	Deep-focus earthquakes	324
6.6	Induced seismicity	326
6.6.1	Seismicity induced by fluid injection	326
6.6.2	Reservoir-induced seismicity	330
6.6.3	Mechanisms of reservoir-induced seismicity	332
6.6.4	Mining-induced seismicity	335
6.6.5	Induced seismicity as a stress gauge	335
7	Earthquake prediction and hazard analysis	337
7.1	Introduction	337
7.1.1	Historical	337
7.1.2	Types of earthquake prediction	338
7.1.3	Is earthquake prediction possible?	340
7.2	Preseismic phenomena	341
7.2.1	Preinstrumental observations	341
7.2.2	Seismicity patterns and precursors	343
7.2.3	Aseismic deformation rate changes prior to earthquakes	352
7.2.4	Other types of reported precursors	357
7.3	Preseismic processes	362
7.3.1	Earthquake nucleation	362
7.3.2	Preseismic dilatancy	364
7.4	Earthquake forecasting in practice	372
7.4.1	Earthquake prediction experiments	372
7.4.2	Earthquake early warning	373
7.4.3	Operational earthquake forecasting	374
7.5	Earthquake hazard analysis	376
7.5.1	Traditional methods	376
7.5.2	Long-term earthquake hazard analysis	377
	References	381
	Index	487