

# La poroplasticité saturée

O. Coussy *Mechanics of Porous Continua / Poromechanics* WILEY & SON 2003

## Plasticité

$$\boldsymbol{\sigma} = \frac{\partial \Psi}{\partial \boldsymbol{\varepsilon}}; \mathbf{A} = -\frac{\partial \Psi}{\partial \alpha}$$

Énergie libre

$$f(\boldsymbol{\sigma}, \mathbf{A}) \leq 0$$

Critère

$$D = \boldsymbol{\sigma} : \dot{\boldsymbol{\varepsilon}} - \dot{\Psi} \\ = \boldsymbol{\sigma} : \dot{\boldsymbol{\varepsilon}}^p + \mathbf{A} \cdot \dot{\alpha} \geq 0$$

Dissipation

## Poro élasticité

$$\varphi = \varphi_0 + b \boldsymbol{\varepsilon} : \mathbf{1} + \frac{p}{N}$$

## Poro plasticité

$$\begin{cases} \boldsymbol{\sigma} = \frac{\partial \Psi_s}{\partial \boldsymbol{\varepsilon}}; \mathbf{A} = -\frac{\partial \Psi_s}{\partial \alpha} \\ p = \frac{\partial \Psi_s}{\partial \varphi} \end{cases}$$

$$f(\boldsymbol{\sigma}, p, \mathbf{A}) \leq 0$$

$$D = \boldsymbol{\sigma} : \dot{\boldsymbol{\varepsilon}} + p \dot{\varphi} - \dot{\Psi}_s \\ = \boldsymbol{\sigma} : \dot{\boldsymbol{\varepsilon}}^p + p \dot{\varphi}^p + \mathbf{A} \cdot \dot{\alpha} \geq 0$$

## Poro plasticité

$$\varphi - \varphi^p = \varphi_0 + b(\boldsymbol{\varepsilon} - \boldsymbol{\varepsilon}^p) : \mathbf{1} + \frac{p}{N}$$

# Poromechanics Mechanics Of Porous Continua

**Wolfgang Ehlers**



## **Poromechanics Mechanics Of Porous Continua:**

**Poromechanics** Olivier Coussy, 2004-03-05 Modelling and predicting how porous media deform when subjected to external actions and physical phenomena including the effect of saturating fluids are of importance to the understanding of geophysics and civil engineering including soil and rock mechanics and petroleum engineering as well as in newer areas such as biomechanics and agricultural engineering Starting from the highly successful First Edition Coussy has completely re-written Mechanics of Porous Continua Poromechanics to include New material for Partially saturated porous media Reactive porous media Macroscopic electrical effects A single theoretical framework to the subject to explain the interdisciplinary nature of the subject Exercises at the end of each chapter to aid understanding The unified approach taken by this text makes it a valuable addition to the bookshelf of every PhD student and researcher in civil engineering petroleum engineering geophysics biomechanics and material science

**Mechanics of Porous Continua** Olivier Coussy, 1995-12-05 This book provides a unified and systematic continuum approach for engineers and applied physicists working on the modelling of porous media Self contained it sets out from a macroscopic point of view the main concepts and results of deformable porous media subject to the flow of one or several fluids The theory presented includes developments in the areas of thermodynamics poroelastoplasticity poroviscoplasticity wave propagation and surfaces of discontinuity boundary value problems and numerical methods as well as chemico mechanical couplings It can be used for numerous diversified applications in geophysics civil engineering biomechanics material science etc

**Poromechanics** J.F. Thimus, et al, 2020-12-17 This text features 105 papers dealing with the fundamentals and the applications of poromechanics from the Biot conference of 1998 held in Louvain la Neuve Topics include wave propagation numerical modelling identification of poromechanical parameters and constitutive modelling

**Poromechanics II** J.L. Auriault, C. Geindreau, P. Royer, J.F. Bloch, 2020-12-18 These proceedings deal with the fundamentals and applications of poromechanics to geomechanics material sciences geophysics acoustics and biomechanics They discuss the state of the art in such topics as constitutive modelling and upscaling methods

**Poromechanics III - Biot Centennial (1905-2005)** Younane N. Abousleiman, Alexander H.-D. Cheung, Franz-Josef Ulm, 2005-05-01 These proceedings represent the latest advances in the mechanics of porous materials known as poromechanics The porous materials considered are solids containing voids that are impregnated with fluid The focus is on the mechanical interactions of the inhomogeneous solid with the single or multi phase fluid under the loading of mechanical force fluid pressure thermal chemical and magnetic fields The response time can be in static diffusional and dynamic ranges The length scale can start from nano to micro macro and up to field scales Its application covers many branches of science and engineering including geophysics geomechanics composite materials biomechanics acoustics seismicity civil mechanical environmental and petroleum engineering The approaches taken include analytical computational and experimental To honor the pioneering contributions of Maurice A Biot 1905 1985 to

poromechanics the Biot Conference on Poromechanics was convened for the first time in Louvain la Neuve Belgium in 1998 The success of the first conference led to the 2nd Biot Conference held in Grenoble France in 2002 To celebrate the centennial birthday of Biot May 25 2005 the 3rd Biot Conference on Poromechanics was held at the University of Oklahoma Norman Oklahoma U S A on May 24 27 2005 Poroelectricity Alexander H.-D. Cheng, 2016-04-20 This book treats the mechanics of porous materials infiltrated with a fluid poromechanics focussing on its linear theory poroelectricity Porous materials from inanimate bodies such as sand soil and rock living bodies such as plant tissue animal flesh or man made materials can look very different due to their different origins but as readers will see the underlying physical principles governing their mechanical behaviors can be the same making this work relevant not only to engineers but also to scientists across other scientific disciplines Readers will find discussions of physical phenomena including soil consolidation land subsidence slope stability borehole failure hydraulic fracturing water wave and seabed interaction earthquake aftershock fluid injection induced seismicity and heat induced pore pressure spalling as well as discussions of seismoelectric and seismoelectromagnetic effects The work also explores the biomechanics of cartilage bone and blood vessels Chapters present theory using an intuitive phenomenological approach at the bulk continuum level and a thermodynamics based variational energy approach at the micromechanical level The physical mechanisms covered extend from the quasi static theory of poroelectricity to poroelectrodynamics poroviscoelasticity porothermoelasticity and porochemoelasticity Closed form analytical solutions are derived in details This book provides an excellent introduction to linear poroelectricity and is especially relevant to those involved in civil engineering petroleum and reservoir engineering rock mechanics hydrology geophysics and biomechanics *Poromechanics IV* Hoe I. Ling, Andrew Smyth, Raimondo Betti, 2009-01-13 Based on the Biot conference named after Maurice Biot and held at Columbia University this book contains over 170 original papers on different phases of poromechanics in many materials from soils and minerals to human bone It covers testing and modeling **IUTAM Symposium on Theoretical and Numerical Methods in Continuum Mechanics of Porous Materials** Wolfgang Ehlers, 2006-04-11 During the last decades continuum mechanics of porous materials has achieved great attention since it allows for the consideration of the volumetrically coupled behaviour of the solid matrix deformation and the pore fluid flow Naturally applications of porous media models range from civil and environmental engineering where e g geotechnical problems like the consolidation problem are of great interest via mechanical engineering where e g the description of sinter materials or polymeric and metallic foams is a typical problem to chemical and biomechanical engineering where e g the complex structure of living tissues is studied Although these applications are principally very different they basically fall into the category of multiphase materials which can be described on the macroscale within the framework of the well founded Theory of Porous Media TPM With the increasing power of computer hardware together with the rapidly decreasing computational costs numerical solutions of complex coupled problems became possible and have been seriously investigated

However since the quality of the numerical solutions strongly depends on the quality of the underlying physical model together with the experimental and mathematical possibilities to successfully determine realistic material parameters a successful treatment of porous materials requires a joint consideration of continuum mechanics experimental mechanics and numerical methods In addition micromechanical investigations and homogenization techniques are very helpful to increase the phenomenological understanding of such media

**Mechanics and Physics of Porous Solids** Olivier Coussy, 2011-06-28  
Mechanics and Physics of Porous Solids addresses the mechanics and physics of deformable porous materials whose porous space is filled by one or several fluid mixtures interacting with the solid matrix Coussy uses the language of thermodynamics to frame the discussion of this topic and bridge the gap between physicists and engineers and organises the material in such a way that individual phases are explored followed by coupled problems of increasing complexity This structure allows the reader to build a solid understanding of the physical processes occurring in the fluids and then porous solids Mechanics and Physics of Porous Solids offers a critical reference on the physics of multiphase porous materials key reading for engineers and researchers in structural and material engineering concrete wood and materials science rock and soil mechanics mining and oil prospecting biomechanics

**Porous Rock Fracture Mechanics** Amir Shojaei, Jianfu Shao, 2017-05-05  
Porous Rock Failure Mechanics Hydraulic Fracturing Drilling and Structural Engineering focuses on the fracture mechanics of porous rocks and modern simulation techniques for progressive quasi static and dynamic fractures The topics covered in this volume include a wide range of academic and industrial applications including petroleum mining and civil engineering Chapters focus on advanced topics in the field of rock s fracture mechanics and address theoretical concepts experimental characterization numerical simulation techniques and their applications as appropriate Each chapter reflects the current state of the art in terms of the modern use of fracture simulation in industrial and academic sectors Some of the major contributions in this volume include but are not limited to anisotropic elasto plastic deformation mechanisms in fluid saturated porous rocks dynamics of fluids transport in fractured rocks and simulation techniques fracture mechanics and simulation techniques in porous rocks fluid structure interaction in hydraulic driven fractures advanced numerical techniques for simulation of progressive fracture including multiscale modeling and micromechanical approaches for porous rocks and quasi static versus dynamic fractures in porous rocks This book will serve as an important resource for petroleum geomechanics drilling and structural engineers R D managers in industry and academia Includes a strong editorial team and quality experts as chapter authors Presents topics identified for individual chapters are current relevant and interesting Focuses on advanced topics such as fluid coupled fractures rock s continuum damage mechanics and multiscale modeling Provides a one stop advanced level reference for a graduate course focusing on rock s mechanics

**Handbook of Materials Behavior Models, Three-Volume Set** Jean LeMaitre, 2001-11-17  
This first of a kind reference handbook deals with nonlinear models and properties of material In the study the behavior of materials phenomena no unique laws exist

Therefore researchers often turn to models to determine the properties of materials This will be the first book to bring together such a comprehensive collection of these models The Handbook deals with all solid materials and is organized first by phenomena Most of the materials models presented in an applications oriented fashion less descriptive and more practitioner geared making it useful in the daily working activities of professionals The Handbook is divided into three volumes Volume I Deformation of Materials introduces general methodologies in the art of modeling in choosing materials and in the so called size effect Chapters 2 5 deal respectively with elasticity and viscoelasticity yield limit plasticity and viscoplasticity Volume II Failures in Materials provides models on such concerns as continuous damage cracking and fracture and friction wear Volume III Multiphysics Behavior deals with multiphysics coupled behaviors Chapter s 10 and 11 are devoted to special classes of materials composites biomaterials and geomaterials The different sections within each chapter describe one model each with its domain of validity its background its formulation the identification of material parameters for as many materials as possible and advice on how to implement or use the model The study of the behavior of materials especially solids is related to hundreds of areas in engineering design and control Predicting how a material will perform under various conditions is essential to determining the optimal performance of machines and vehicles and the structural integrity of buildings as well as safety issues Such practical examples would be how various new materials such as those used in new airplane hulls react to heat or cold or sudden temperature changes or how new building materials hold up under extreme earthquake conditions The Handbook of Materials Behavior Models Gathers together 117 models of behavior of materials written by the most eminent specialists in their field Presents each model s domain of validity a short background its formulation a methodology to identify the materials parameters advise on how to use it in practical applications as well as extensive references Covers all solid materials metals alloys ceramics polymers composites concrete wood rubber geomaterials such as rocks soils sand clay biomaterials etc Concerns all engineering phenomena elasticity viscoelasticity yield limit plasticity viscoplasticity damage fracture friction and wear

*Applied Micromechanics of Porous Materials* Luc Dormieux, Franz-Josef Ulm, 2007-03-23 Poromechanics is the mechanics of porous materials and is now a well established field in many engineering disciplines ranging from Civil Engineering Geophysics Petroleum Engineering to Bioengineering However a rigorous approach that links the physics of the phenomena at stake in porous materials and the macroscopic behaviour is still missing This book presents such an approach by means of homogenization techniques Rigorously founded in various theories of micromechanics these up scaling techniques are developed for the homogenization of transport properties stiffness and strength properties of porous materials The special feature of this book is the balance between theory and application providing the reader with a comprehensive introduction to state of the art homogenization theories and applications to a large range of real life porous materials concrete rocks shales bones etc

**Mechanics of Unsaturated Geomaterials** Lyessse Laloui, 2013-03-04 This book provides a sound basis in the challenging area of the mechanics of

unsaturated geomaterials The objective is to supply the reader with an exhaustive overview starting from the basics and covering the most recent theories and applications i e natural disasters nuclear waste disposal oil and agriculture productions The presentation of the fundamental concepts is based on an interdisciplinary approach in the areas of soil rock and cement based material mechanics      *Unsaturated Soils, Two Volume Set* Olivier Buzzi, S. Fityus, D. Sheng, 2009-11-02

Unsaturated soil mechanics is now increasingly recognized as an integral part of mainstream soil mechanics and the importance and relevance of unsaturated soil mechanics for the broad field of geotechnical engineering no longer needs to be emphasized The two volumes making up *Unsaturated soils* include papers from the 4th Asia Pacific Conference      **Structural Geology** Bruce E. Hobbs, Alison Ord, 2014-11-21 *Structural Geology* is a groundbreaking reference that introduces you to the concepts of nonlinear solid mechanics and non equilibrium thermodynamics in metamorphic geology offering a fresh perspective on rock structure and its potential for new interpretations of geological evolution This book stands alone in unifying deformation and metamorphism and the development of the mineralogical fabrics and the structures that we see in the field This reflects the thermodynamics of systems not at equilibrium within the framework of modern nonlinear solid mechanics The thermodynamic approach enables the various mechanical thermal hydrological and chemical processes to be rigorously coupled through the second law of thermodynamics invariably leading to nonlinear behavior The book also differs from others in emphasizing the implications of this nonlinear behavior with respect to the development of the diverse complex even fractal range of structures in deformed metamorphic rocks Building on the fundamentals of structural geology by discussing the nonlinear processes that operate during the deformation and metamorphism of rocks in the Earth's crust the book's concepts help geoscientists and graduate level students understand how these processes control or influence the structures and metamorphic fabrics providing applications in hydrocarbon exploration ore mineral exploration and architectural engineering Authored by two of the world's foremost experts in structural geology representing more than 70 years of experience in research and instruction Nearly 300 figures illustrations working examples and photographs reinforce key concepts and underscore major advances in structural geology      *Numerical Modeling of Concrete Cracking* Guenter Hofstetter, Guenther Meschke, 2011-10-08 The book presents the underlying theories of the different approaches for modeling cracking of concrete and provides a critical survey of the state of the art in computational concrete mechanics It covers a broad spectrum of topics related to modeling of cracks including continuum based and discrete crack models meso scale models advanced discretization strategies to capture evolving cracks based on the concept of finite elements with embedded discontinuities and on the extended finite element method and extensions to coupled problems such as hygro mechanical problems as required in computational durability analyses of concrete structures      **Continuum Thermodynamics - Part I: Foundations** Krzysztof Wilmanski, 2008-11-25 This book is a unique presentation of thermodynamic methods of construction of continuous models It is based on a uniform approach following from the entropy inequality and using

Lagrange multipliers as auxiliary quantities in its evaluation It covers a wide range of models ideal gases thermoviscoelastic fluids thermoelastic and thermoviscoelastic solids plastic polycrystals miscible and immiscible mixtures and many others The structure of phenomenological thermodynamics is justified by a systematic derivation from the Liouville equation through the BBGKY hierarchy derived Boltzmann equation to an extended thermodynamics In order to simplify the reading an extensive introduction to classical continuum mechanics and thermostatics is included As a complementary volume to Part II which will contain applications and examples and to Part III which will cover numerical methods only a few simple examples are presented in this first Part One exception is an extensive example of a linear poroelastic material because it will not appear in future Parts The book is the first presentation of continuum thermodynamics in which foundations of continuum mechanics microscopic foundations and transition to extended thermodynamics applications of extended thermodynamics beyond ideal gases and thermodynamic foundations of various material theories are exposed in a uniform and rational way The book may serve both as a support for advanced courses as well as a desk reference

### **Continuum Thermodynamics - Part I**

Krzysztof Wilmanski, 2008 This book is a unique presentation of thermodynamic methods of construction of continuous models It is based on a uniform approach following from the entropy inequality and using Lagrange multipliers as auxiliary quantities in its evaluation It covers a wide range of models OCo ideal gases thermoviscoelastic fluids thermoelastic and thermoviscoelastic solids plastic polycrystals miscible and immiscible mixtures and many others The structure of phenomenological thermodynamics is justified by a systematic derivation from the Liouville equation through the BBGKY hierarchy derived Boltzmann equation to an extended thermodynamics In order to simplify the reading an extensive introduction to classical continuum mechanics and thermostatics is included As a complementary volume to Part II which will contain applications and examples and to Part III which will cover numerical methods only a few simple examples are presented in this first Part One exception is an extensive example of a linear poroelastic material because it will not appear in future Parts The book is the first presentation of continuum thermodynamics in which foundations of continuum mechanics microscopic foundations and transition to extended thermodynamics applications of extended thermodynamics beyond ideal gases and thermodynamic foundations of various material theories are exposed in a uniform and rational way The book may serve both as a support for advanced courses as well as a desk reference

### **Continuum Thermodynamics** Wilmanski, 2008

This book is a unique presentation of thermodynamic methods of construction of continuous models It is based on a uniform approach following from the entropy inequality and using Lagrange multipliers as auxiliary quantities in its evaluation It covers a wide range of models ideal gases thermoviscoelastic fluids thermoelastic and thermoviscoelastic solids plastic polycrystals miscible and immiscible mixtures and many others The structure of phenomenological thermodynamics is justified by a systematic derivation from the Liouville equation through the BBGKY hierarchy derived Boltzmann equation to an extended thermodynamics In order to simplify the reading an extensive introduction to classical continuum mechanics and



thermostatistics is included As a complementary volume to Part II which will contain applications and examples and to Part III which will cover numerical methods only a few simple examples are presented in this first Part One exception is an extensive example of a linear poroelastic material because it will not appear in future Parts The book is the first presentation of continuum thermodynamics in which foundations of continuum mechanics microscopic foundations and transition to extended thermodynamics applications of extended thermodynamics beyond ideal gases and thermodynamic foundations of various material theories are exposed in a uniform and rational way The book may serve both as a support for advanced courses as well as a desk reference     Deformation Mechanisms, Rheology and Tectonics David J. Prior, Ernest Henry Rutter, Daniel J. Tatham, 2011 This collection of papers presents recent advances in the study of deformation mechanisms and rheology and their applications to tectonics Many of the contributions exploit new petrofabric techniques particularly electron backscatter diffraction to help understand the evolution of rock microstructure and mechanical properties Papers in the first section lattice preferred orientations and anisotropy show a growing emphasis on the determination of elastic properties from petrofabrics from which acoustic properties can be computed for comparison with in situ seismic measurements Such research will underpin geodynamic interpretation of large scale active tectonics Contributions in the second section microstructures mechanisms and rheology study the relations between microstructural evolution during deformation and mechanical properties

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