



**CONCEPTUAL
MODELS OF
FLOW AND TRANSPORT
IN THE
FRACTURED
VADOSE
ZONE**

Conceptual Models Of Flow And Transport In The Fractured Vadose Zone

Hui-Hai Liu



Conceptual Models Of Flow And Transport In The Fractured Vadose Zone:

Conceptual Models of Flow and Transport in the Fractured Vadose Zone National Research Council, Commission on Geosciences, Environment, and Resources, Board on Earth Sciences and Resources, U.S. National Committee for Rock Mechanics, Panel on Conceptual Models of Flow and Transport in the Fractured Vadose Zone, 2001-06-21 Fluid flow and solute transport within the vadose zone the unsaturated zone between the land surface and the water table can be the cause of expanded plumes arising from localized contaminant sources An understanding of vadose zone processes is therefore an essential prerequisite for cost effective contaminant remediation efforts In addition because such features are potential avenues for rapid transport of chemicals from contamination sources to the water table the presence of fractures and other channel like openings in the vadose zone poses a particularly significant problem Conceptual Models of Flow and Transport in the Fractured Vadose Zone is based on the work of a panel established under the auspices of the U S National Committee for Rock Mechanics It emphasizes the importance of conceptual models and goes on to review the conceptual model development testing and refinement processes The book examines fluid flow and transport mechanisms noting the difficulty of modeling solute transport and identifies geochemical and environmental tracer data as important components of the modeling process Finally the book recommends several areas for continued research

A Chaotic-Dynamical Conceptual Model to Describe Fluid Flow and Contaminant Transport in a Fractured Vadose Zone, 1999

- 1 To determine if and when dynamical chaos theory can be used to investigate infiltration of fluid and contaminant transport in heterogeneous soils and fractured rocks
- 2 To introduce a new approach to the multiscale characterization of flow and transport in fractured basalt vadose zones and to develop physically based conceptual models on a hierarchy of scales

The following activities are indicative of the success in meeting the project's objectives A series of ponded infiltration tests including

- 1 small scale infiltration tests ponded area 0.5 m² conducted at the Hell's Half Acre site near Shelley Idaho and
- 2 intermediate scale infiltration tests ponded area 56 m² conducted at the Box Canyon site near Arco Idaho

Laboratory investigations and modeling of flow in a fractured basalt core A series of small scale dripping experiments in fracture models Evaluation of chaotic behavior of flow in laboratory and field experiments using methods from nonlinear dynamics Evaluation of the impact these dynamics may have on contaminant transport through heterogeneous fractured rocks and soils and how it can be used to guide remediation efforts Development of a conceptual model and mathematical and numerical algorithms for flow and transport that incorporate

- 1 the spatial variability of heterogeneous porous and fractured media and
- 2 the description of the temporal dynamics of flow and transport both of which may be chaotic

Development of appropriate experimental field and laboratory techniques needed to detect diagnostic parameters for chaotic behavior of flow This approach is based on the assumption that spatial heterogeneity and flow phenomena are affected by nonlinear dynamics and in particular by chaotic processes The scientific and practical value of this approach is that we can predict the range within which the parameters of

flow and transport change with time in order to design and manage the remediation even when we can not predict the behavior at any point or time *Chaotic-Dynamical Conceptual Model to Describe Fluid Flow and Contaminant Transport in a Fractured Vadose Zone* ,1999 DOE faces the remediation of numerous contaminated sites such as those at Hanford INEEL LLNL and LBNL where organic and or radioactive wastes were intentionally or accidentally released to the vadose zone from surface spills underground tanks cribs shallow ponds and deep wells Migration of these contaminants through the vadose zone has led to the contamination of or threatens to contaminate underlying groundwater A key issue in choosing a corrective action plan to clean up contaminated sites is the determination of the location total mass mobility and travel time to receptors for contaminants moving in the vadose zone These problems are difficult to solve in a technically defensible and accurate manner because contaminants travel downward intermittently through narrow pathways driven by variations in environmental conditions These preferential flow pathways can be difficult to find and predict The primary objective of this project is to determine if and when dynamical chaos theory can be used to investigate infiltration of fluid and contaminant transport in heterogeneous soils and fractured rocks The objective of this project is being achieved through the following activities Development of multi scale conceptual models and mathematical and numerical algorithms for flow and transport which incorporate both a the spatial variability of heterogeneous porous and fractured media and b the temporal dynamics of flow and transport Development of appropriate experimental field and laboratory techniques needed to detect diagnostic parameters for chaotic behavior of flow Evaluation of chaotic behavior of flow in laboratory and field experiments using methods from non linear dynamics Evaluation of the impact these dynamics may have on contaminant transport through heterogeneous fractured rocks and soils and remediation efforts This approach is based on the consideration of multi scale spatial heterogeneity and flow phenomena that are affected by nonlinear dynamics and in particular chaotic processes The scientific and practical value of this approach is that we can predict the range within which the parameters of flow and transport change with time which allows us to design and manage the remediation even when we cannot predict the behavior at any point or time **Fluid Dynamics in Complex Fractured-Porous Systems** Boris Faybishenko,Sally M. Benson,John E. Gale,2015-06-15 Despite of many years of studies predicting fluid flow heat and chemical transport in fractured porous media remains a challenge for scientists and engineers worldwide This monograph is the third in a series on the dynamics of fluids and transport in fractured rock published by the American Geophysical Union Geophysical Monograph Series Vol 162 2005 and Geophysical Monograph No 122 2000 This monograph is dedicated to the late Dr Paul Witherspoon for his seminal influence on the development of ideas and methodologies and the birth of contemporary fractured rock hydrogeology including such fundamental and applied problems as environmental remediation exploitation of oil gas and geothermal resources disposal of spent nuclear fuel and geotechnical engineering This monograph addresses fundamental and applied scientific questions and is intended to assist scientists and practitioners bridge gaps in the current scientific knowledge in

the areas of theoretical fluids dynamics field measurements and experiments for different practical applications Readers of this book will include researchers engineers and professionals within academia Federal agencies and industry as well as graduate undergraduate students involved in theoretical experimental and numerical modeling studies of fluid dynamics and reactive chemical transport in the unsaturated and saturated zones including studies pertaining to petroleum and geothermal reservoirs environmental management and remediation mining gas storage and radioactive waste isolation in underground repositories Volume highlights include discussions of the following Fundamentals of using a complex systems approach to describe flow and transport in fractured porous media Methods of Field Measurements and Experiments Collective behavior and emergent properties of complex fractured rock systems Connection to the surrounding environment Multi disciplinary research for different applications Subsurface Solute Transport Models and Case Histories Vyacheslav G.

Rumynin,2012-01-14 The book addresses the development of the basic knowledge of the subsurface solute transfer with a particular emphasis on field data collection and analysis coupled with modeling analytical and numerical tool application The relevant theoretical developments are concerned mainly with the formulation and solution of deterministic mass transport equations for a wide range of engineering issues in groundwater quality assessment and forecasting The book gives many computational examples and case studies drawn from the conducted field investigations The analyzed problems are as follows investigation and prediction of groundwater contamination by industrial contaminants and solutions radionuclides chloride and nitrate brine with special focus on the effect of a aquifer heterogeneity anisotropy and dual porosity b density contrast existing between industrial waste and groundwater or in density stratified artesian and coastal groundwater systems c physicochemical interactions that play a major role in retarding e g adsorption or enhancing e g interactions between dissolved species and mobile colloids contaminant transport prediction of the effects of pumping on groundwater quality at wellfields groundwater dating using stable and radioactive isotopes for prediction and assessment of contamination potential field and laboratory tests design and analysis and monitoring data interpretation partitioning of surface and subsurface flows using isotope techniques One of the most essential topics addressed in the book is the migration and fate of radionuclides Model development is motivated by field data analysis from a number of radioactively contaminated sites in the Russian Federation near surface radioactive waste disposal sites and deep well radioactive waste injection sites They play a unique role in the advancement of knowledge of the subsurface behavior and fate of many hazardous radionuclides and can be considered as field scale laboratories Thus the book along with theoretical findings contains field information which will facilitate the understanding of subsurface solute transport and the development of a methodology for practical applications to groundwater hydrology *Weekly Information Report* ,1998-07 **Transport and Reactivity of Solutions in**

Confined Hydrosystems Lionel Mercury,Niels Tas,Michael Zilberbrand,2013-11-12 The present work reflects a multi disciplinary effort to address the topic of confined hydrosystems developed with a cross fertilization panel of physics chemists

biologists soil and earth scientists Confined hydrosystems include all situations in natural settings wherein the extent of the liquid phase is limited so that the solid liquid and or liquid air interfaces may be critical to the properties of the whole system Primarily this so called residual solution is occluded in pores channels in such a way that decreases its tendency to evaporation and makes it long lasting in arid Earth deserts and hyper arid Mars soils areas The associated physics is available from domains like capillarity adsorption and wetting and surface forces However many processes are still to understand due to the close relationship between local structure and matter properties the subtle interplay between the host and the guest the complex intermingling among static reactivity and migration pathway Expert contributors from Israel Russia Europe and US discuss the behaviour of water and aqueous solutes at different scale from the nanometric range of carbon nanotubes and nanofluidics to the regional scale of aquifers reactive flow in sedimentary basins This scientific scope allowed the group of participants with very different background to tackle the confinement topic at different scales The book is organized according to four sections that include i flow from nano to mega scale ii ions hydration and transport iii in pores channels cavitation iv crystallization under confinement Most of contributions relates to experimental works at different resolution interpreted through classic thermodynamics and intermolecular forces Simulation techniques are used to explore the atomic scale of interfaces and the migration in the thinnest angstrom wide channels

A Chaotic-dynamical Conceptual Model to Describe Fluid Flow and Contaminant Transport in a Fractured Vadose Zone. 1997 Annual Progress Report, 1997 Understanding subsurface flow and transport processes is critical for effective assessment decision making and remediation activities for contaminated sites However for fluid flow and contaminant transport through fractured vadose zones traditional hydrogeological approaches are often found to be inadequate In this project the authors examine flow and transport through a fractured vadose zone as a deterministic chaotic dynamical process and develop a model of it in these terms Initially they examine separately the geometric model of fractured rock and the flow dynamics model needed to describe chaotic behavior Ultimately they will put the geometry and flow dynamics together to develop a chaotic dynamical model of flow and transport in a fractured vadose zone They investigate water flow and contaminant transport on several scales ranging from small scale laboratory experiments in fracture replicas and fractured cores to field experiments conducted in a single exposed fracture at a basalt outcrop and finally to a ponded infiltration test using a pond of 7 by 8 m In the field experiments the authors measure the time variation of water flux moisture content and hydraulic head at various locations as well as the total inflow rate to the subsurface Such variations reflect the changes in the geometry and physics of water flow that display chaotic behavior which the authors try to reconstruct using the data obtained In the analysis of experimental data a chaotic model can be used to predict the long term bounds on fluid flow and transport behavior known as the attractor of the system and to examine the limits of short term predictability within these bounds This approach is especially well suited to the need for short term predictions to support remediation decisions and long term bounding studies

Handbook of Soil Sciences (Two Volume Set) Pan Ming Huang, Yuncong Li, Malcolm E. Sumner, 2018-10-03 An evolving living organic inorganic covering soil is in dynamic equilibrium with the atmosphere above the biosphere within and the geology below It acts as an anchor for roots a purveyor of water and nutrients a residence for a vast community of microorganisms and animals a sanitizer of the environment and a source of raw materials for co **NCRP Report** National Council on Radiation Protection and Measurements, 1966 **The Handbook of Groundwater Engineering, Third Edition** John H. Cushman, Daniel M. Tartakovsky, 2016-11-25 This new edition adds several new chapters and is thoroughly updated to include data on new topics such as hydraulic fracturing CO₂ sequestration sustainable groundwater management and more Providing a complete treatment of the theory and practice of groundwater engineering this new handbook also presents a current and detailed review of how to model the flow of water and the transport of contaminants both in the unsaturated and saturated zones covers the protection of groundwater and the remediation of contaminated groundwater

Scaling Methods in Soil Physics Yakov Pachepsky, David E. Radcliffe, H. Magdi Selim, 2003-03-26 The scaling issue remains one of the largest problems in soil science and hydrology This book is a unique compendium of ideas conceptual approaches techniques and methodologies for scaling soil physical properties *Scaling Methods in Soil Physics* covers many methods of scaling that will be useful in helping scientists across a range of soil rel *Rainfall-Induced Soil Slope Failure* Lulu Zhang, Jinhui Li, Xu Li, Jie Zhang, Hong Zhu, 2018-09-03 Rainfall induced landslides are common around the world With global climate change their frequency is increasing and the consequences are becoming greater Previous studies assess them mostly from the perspective of a single discipline correlating landslides with rainstorms geomorphology and hydrology in order to establish a threshold prediction value for rainfall induced landslides analyzing the slope s stability using a geomechanical approach or assessing the risk from field records *Rainfall Induced Soil Slope Failure Stability Analysis and Probabilistic Assessment* integrates probabilistic approaches with the geotechnical modeling of slope failures under rainfall conditions with unsaturated soil It covers theoretical models of rainfall infiltration and stability analysis reliability analysis based on coupled hydro mechanical modelling stability of slopes with cracks gravels and spatial heterogenous soils and probabilistic model calibration based on measurement It focuses on the uncertainties involved with rainfall induced landslides and presents state of the art techniques and methods which characterize the uncertainties and quantify the probabilities and risk of rainfall induced landslide hazards Additionally the authors cover The failure mechanisms of rainfall induced slope failure Commonly used infiltration and stability methods The infiltration and stability of natural soil slopes with cracks and colluvium materials Stability evaluation methods based on probabilistic approaches The effect of spatial variability on unsaturated soil slopes and more **Improving the Regulation and Management of Low-Activity Radioactive Wastes** National Research Council, Division on Earth and Life Studies, Nuclear and Radiation Studies Board, Committee on Improving Practices for Regulating and Managing Low-Activity Radioactive Waste, 2006-05-24 The

largest volumes of radioactive wastes in the United States contain only small amounts of radioactive material. These low activity wastes LAW come from hospitals, utilities, research institutions and defense installations where nuclear material is used. Millions of cubic feet of LAW also arise every year from non nuclear enterprises such as mining and water treatment. While LAW present much less of a radiation hazard than spent nuclear fuel or high level radioactive wastes, they can cause health risks if controlled improperly. Improving the Regulation and Management of Low Activity Radioactive Wastes asserts that LAW should be regulated and managed according to the degree of risk they pose for treatment, storage and disposal. Current regulations are based primarily on the type of industry that produced the waste, the waste's origin rather than its risk. In this report, a risk informed approach for regulating and managing all types of LAW in the United States is proposed. Implemented in a gradual or stepwise fashion, this approach combines scientific risk assessment with public values and perceptions. It focuses on the hazardous properties of the waste in question and how they compare with other waste materials. The approach is based on established principles for risk informed decision making, current risk informed initiatives by waste regulators in the United States and abroad, solutions available under current regulatory authorities and remedies through new legislation when necessary.

One Step at a Time National Research Council, Division on Earth and Life Studies, Board on Radioactive Waste Management, Committee on Principles and Operational Strategies for Staged Repository Systems, 2003-03-10. Compared to other large engineering projects, geologic repositories for high level waste present distinctive challenges because 1) they are first of a kind, complex and long term projects that must actively manage hazardous materials for many decades; 2) they are expected to hold these hazardous materials passively safe for many millennia after repository closure; and 3) they are widely perceived to pose serious risks. As is the case for other complex projects, repository programs should proceed in stages. One Step at a Time focuses on a management approach called adaptive staging, as a promising means to develop geologic repositories for high level radioactive waste such as the proposed repository at Yucca Mountain, Nevada. Adaptive staging is a learn as you go process that enables project managers to continuously reevaluate and adjust the program in response to new knowledge and stakeholder input. Advice is given on how to implement staging during the construction, operation, closure and post closure phases of a repository program.

Soil Management and Climate Change Maria Angeles Munoz, Raúl Zornoza, 2017-10-16. Soil Management and Climate Change Effects on Organic Carbon Nitrogen Dynamics and Greenhouse Gas Emissions provides a state of the art overview of recent findings and future research challenges regarding physical, chemical and biological processes controlling soil carbon, nitrogen dynamic and greenhouse gas emissions from soils. This book is for students and academics in soil science and environmental science, land managers, public administrators and legislators and will increase understanding of organic matter preservation in soil and mitigation of greenhouse gas emissions. Given the central role soil plays on the global carbon (C) and nitrogen (N) cycles and its impact on greenhouse gas emissions, there is an urgent need to increase our common understanding about sources, mechanisms and

processes that regulate organic matter mineralization and stabilization and to identify those management practices and processes which mitigate greenhouse gas emissions helping increase organic matter stabilization with suitable supplies of available N Provides the latest findings about soil organic matter stabilization and greenhouse gas emissions Covers the effect of practices and management on soil organic matter stabilization Includes information for readers to select the most suitable management practices to increase soil organic matter stabilization

Fluid Flow in the Subsurface Hui-Hai Liu, 2016-08-31 This book presents a systematic attempt to generalize several fundamental physical laws related to subsurface fluid flow that are important for a number of contemporary applications in the areas of hydrogeology reservoir engineering and rock mechanics It also covers the history of discovering these physical laws their respective scope of validity and their generalizations or extensions The physical laws discussed include Darcy's law Darcy Buckingham law and Hooke's law Darcy's law is the fundamental law for subsurface fluid flow For low permeability media it is not always adequate because of the strong fluid solid interaction Though the Darcy Buckingham law is often used for modeling subsurface multiphase flow it is only valid under the local equilibrium condition This condition does not hold in many cases especially when fingering flow occurs It is well known that subsurface fluid flow is coupled with mechanical deformation of subsurface media in some applications this coupling can play a dominant role The continuum scale elastic deformation of natural rock however does not always follow the traditional form of Hooke's law The book also presents applications of the proposed generalizations of the physical laws to several important engineering projects

Management of Contaminated Site Problems, Second Edition Kofi Asante-Duah, 2019-04-12 This book outlines the strategies used in the investigation characterization management and restoration and remediation for various contaminated sites It draws on real world examples from across the globe to illustrate remediation techniques and discusses their applicability It provides guidance for the successful corrective action assessment and response programs for any type of contaminated land problem and at any location The systematic protocols presented will aid environmental professionals in managing contaminated land and associated problems more efficiently This new edition adds twelve new chapters and is fully updated and expanded throughout

Water-quality data from 2002 to 2003 and analysis of data gaps for development of total maximum daily loads in the lower Klamath River basin, California , **Encyclopedia of Agrophysics** Jan Gliński, Józef

Horabik, Jerzy Lipiec, 2011-06-07 This Encyclopedia of Agrophysics will provide up to date information on the physical properties and processes affecting the quality of the environment and plant production It will be a first up volume which will nicely complement the recently published Encyclopedia of Soil Science November 2007 which was published in the same series In a single authoritative volume a collection of about 250 informative articles and ca 400 glossary terms covering all aspects of agrophysics will be presented The authors will be renowned specialists in various aspects in agrophysics from a wide variety of countries Agrophysics is important both for research and practical use not only in agriculture but also in

areas like environmental science land reclamation food processing etc Agrophysics is a relatively new interdisciplinary field closely related to Agrochemistry Agrobiology Agroclimatology and Agroecology Nowadays it has been fully accepted as an agricultural and environmental discipline As such this Encyclopedia volume will be an indispensable working tool for scientists and practitioners from different disciplines like agriculture soil science geosciences environmental science geography and engineering

Whispering the Strategies of Language: An Mental Quest through **Conceptual Models Of Flow And Transport In The Fractured Vadose Zone**

In a digitally-driven earth where monitors reign supreme and quick interaction drowns out the subtleties of language, the profound strategies and emotional subtleties hidden within words usually move unheard. Yet, located within the pages of **Conceptual Models Of Flow And Transport In The Fractured Vadose Zone** a captivating fictional treasure pulsating with organic thoughts, lies a fantastic journey waiting to be undertaken. Published by a skilled wordsmith, this marvelous opus encourages readers on an introspective trip, softly unraveling the veiled truths and profound affect resonating within ab muscles cloth of each word. Within the mental depths of this emotional review, we can embark upon a sincere exploration of the book is primary styles, dissect their charming writing fashion, and yield to the effective resonance it evokes heavy within the recesses of readers hearts.

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