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Geothermal Energy From Theoretical Models To Exploration And Development

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Flow and Heat Transfer in Geothermal Systems

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Geothermal Heat Pumps
Low-Temperature Energy Systems with Applications of Renewable Energy
Hydraulic fracturing and geothermal energy
Reactive Transport Modeling
Final Report of Geothermal Energy and High-Performance Drilling Collaborative Research Program (gebo)

Geothermal Energy From Theoretical Models To Exploration And Development

OMB No. 5597810647634 edited by

KAELYN TRUJILLO

Flow and Heat Transfer in Geothermal Systems
Springer
During the oil crisis of 1973, we suddenly became aware that fossil fuel resources are limited and will be exhausted soon if new alternatives are not put into use immediately. Conservation measures and extensive research on new sources of energy has eased the demand on fossil fuels, especially crude oil.

Geothermal energy as an alternative; source had its share in this devel opment and electricity producing capacity increased from 700 to 4700 MWe during 1970 to 1985. Geothermal reservoir engineering emerged as an impor tant field in the assessment of geothermal sources. During the 25 years of its development, several areas were identified that needed further at tention for the correct description and interpretation of reservoir be havior. This fact as accepted by all operators is vital for the steady and continuous operation of power plants. During this NATO ASI, a detailed review of theory and field case his tories on geothermal reservoir engineering was presented. In understanding .the reservoir, conceptual models, natural state models, well bore measure ments, transient and tracer testing provide data which are indispensable. They are powerful tools in understanding reservoir behavior provided we know how to interpret them. During lectures the theory and practical applications of these interpretive methods were discussed.

Geothermal Energy Utilization and Technologies 2020

Elsevier

Teaches the application of Reactive Transport Modeling (RTM) for subsurface systems in order to expedite the understanding of the behavior of complex

geological systems This book lays out the basic principles and approaches of Reactive Transport Modeling (RTM) for surface and subsurface environments, presenting specific workflows and applications. The techniques discussed are being increasingly commonly used in a wide range of research fields, and the information provided covers fundamental theory, practical issues in running reactive transport models, and how to apply techniques in specific areas. The need for RTM in engineered facilities, such as nuclear waste repositories or CO2 storage sites, is ever increasing, because the prediction of the future evolution of these systems has become a legal obligation. With increasing recognition of the power of these approaches, and their widening adoption, comes responsibility to ensure appropriate application of available tools. This book aims to provide the requisite understanding of key aspects of RTM, and in doing so help identify and thus avoid potential pitfalls. Reactive Transport Modeling covers: the application of RTM for CO2 sequestration and geothermal energy development; reservoir quality prediction; modeling diagenesis; modeling geochemical processes in oil & gas production; modeling gas hydrate production; reactive transport in fractured and porous media;

reactive transport studies for nuclear waste disposal; reactive flow modeling in hydrothermal systems; and modeling biogeochemical processes. Key features include: A comprehensive reference for scientists and practitioners entering the area of reactive transport modeling (RTM) Presented by internationally known experts in the field Covers fundamental theory, practical issues in running reactive transport models, and hands-on examples for applying techniques in specific areas Teaches readers to appreciate the power of RTM and to stimulate usage and application Reactive Transport Modeling is written for graduate students and researchers in academia, government laboratories, and industry who are interested in applying reactive transport modeling to the topic of their research. The book will also appeal to geochemists, hydrogeologists, geophysicists, earth scientists, environmental engineers, and environmental chemists.

Advances in Renewable Energies and Power Technologies Prabhat Prakashan

This final report describes the results of a research program we carried out over a five-year (3/1999-9/2004) period with funding from a Department of Energy geothermal FDP grant (DE-FG07-99ID13745) and

from other agencies. The goal of research projects in this program were to develop modeling technologies that can increase the understanding of geothermal reservoir chemistry and chemistry-related energy production processes. The ability of computer models to handle many chemical variables and complex interactions makes them an essential tool for building a fundamental understanding of a wide variety of complex geothermal resource and production chemistry. With careful choice of methodology and parameterization, research objectives were to show that chemical models can correctly simulate behavior for the ranges of fluid compositions, formation minerals, temperature and pressure associated with present and near future geothermal systems as well as for the very high PT chemistry of deep resources that is intractable with traditional experimental methods. Our research results successfully met these objectives. We demonstrated that advances in physical chemistry theory can be used to accurately describe the thermodynamics of solid-liquid-gas systems via their free energies for wide ranges of composition (X), temperature and pressure. Eight articles on this work were published in peer-reviewed journals and

in conference proceedings. Four are in preparation. Our work has been presented at many workshops and conferences. We also considerably improved our interactive web site (geotherm.ucsd.edu), which was in preliminary form prior to the grant. This site, which includes several model codes treating different XPT conditions, is an effective means to transfer our technologies and is used by the geothermal community and other researchers worldwide. Our models have wide application to many energy related and other important problems (e.g., scaling prediction in petroleum production systems, stripping towers for mineral production processes, nuclear waste storage, CO2 sequestration strategies, global warming). Although funding decreases cut short completion of several research activities, we made significant progress on these abbreviated projects.

Thermal Use of Shallow Groundwater

CRC Press

The internal heat of the planet Earth represents an inexhaustible reservoir of thermal energy. This form of energy, known as geothermal energy has been utilized throughout human history in the form of hot water from hot springs. Modern utilization of geothermal energy includes direct use of

the heat and its conversion to other forms of energy, mainly electricity. Geothermal energy is a form of renewable energy and its use is associated with very little or no CO2-emissions and its importance as an energy source has greatly increased as the effects of climate change become more prominent. Because of its inexhaustibility it is obvious that utilization of geothermal energy will become a cornerstone of future energy supplies. The exploration of geothermal resources has become an important topic of study as geology and earth science students prepare to meet the demands of a rapidly growing industry, which involves an increasing number professionals and public institutions participating in geothermal energy related projects. This book meets the demands of both groups of readers, students and professionals. Geothermal Energy and its utilization is systematically presented and contains the necessary technical information needed for developing and understanding geothermal energy projects. It presents basic knowledge on the Earth's thermal regime and its geothermal energy resources, the types of geothermal energy used as well as its future potential and the perspectives of the industry. Specific chapters of the book deal with borehole heat

exchangers and with the direct use of groundwater and thermal water in hydrogeothermal systems. A central topic are Enhanced Geothermal Systems (hot-dry-rock systems), a key technology for energy supply in the near future. Pre-drilling site investigations, drilling technology, well logging and hydraulic test programs are important subjects related to the exploration phase of developing Geothermal Energy sites. The chemical composition of the natural waters used as a heat transport medium in geothermal systems can be used as an exploration tool, but chemistry is also important during operation of a geothermal power plant because of potential scale formation and corrosion of pipes and installations, which needs to be prevented. Graduate students and professionals will find in depth information on Geothermal Energy, its exploration and utilization.

Shallow Geothermal Energy

Springer
A comprehensive reference to renewable energy technologies with a focus on power generation and integration into power systems This book addresses the generation of energy (primarily electrical) through various renewable sources. It discusses solar and wind power—two major

resources that are now in use in small as well as large-scale power production—and their requirements for effectively using advanced control techniques.In addition, the book looks at theintegration of renewable energy in the power grid and its ability to work in a micro grid. Operation and Control of Renewable Energy Systems describes the numerous types of renewable energy sources available and the basic principles involving energy conversion, including the theory of fluid mechanics and the laws of thermodynamics. Chapter coverage includes the theory of power electronics and various electric power generators, grid scale energy storage systems, photovoltaic power generation, solar thermal energy conversion technology, horizontal and vertical wind turbines for power generation, and more. Covers integration into power systems with an emphasis on microgrids Introduces a wide range of subjects related to renewable energy systems, including energy storage, microgrids, and battery technologies Includes tutorial materials such as up-to-date references for wind energy, grid connection, and power electronics—plus worked examples and solutions Operation and Control of Renewable Energy Systems is the perfect introduction to

renewable energy technologies for undergraduate and graduate students and can also be very useful to practicing engineers.

A Method of Fundamental Solutions in Poroelasticity to Model the Stress Field in Geothermal Reservoirs

Springer

The superior goal of the gebo research association was making important contributions for the future reliable drilling under the existing “hot-hard-rock” conditions in Niedersachsen and their development to the geothermal drillings with sustainable geological subsurface heat exchangers. This goal should be achieved due to the solid research and innovative technology approaches in their combination within one concept for pioneering methods in deep geothermal drillings in hard rock, to be more exact - in interdisciplinary cooperation on engineers and scientists - in cooperation between industry and University, researchers and users Gebo research association comprised scientists and technicians of different research institutions and universities who are working in 33 projects. The individual projects were assigned to one of the 4 main research fields or focus areas.

Gebo research association started its activities with 7 project partners participating: - Technische Universität Braunschweig (TUBS) - Technische Universität Clausthal (TUC) - Gottfried Wilhelm Leibniz Universität Hannover (LUH) - Georg-August-Universität Göttingen (UGOE) - Leibniz-Institut für Angewandte Geophysik (LIAG) - Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) - Energie-Forschungszentrum Niedersachsen (EFZN) Baker Hughes, an industrial partner, participated in the association and supplies it with its experience and additional funds.

Geothermal Reservoir Engineering

Birkhäuser Geothermal Heat Pumps is the most comprehensive guide to the selection, design and installation of geothermal heat pumps available. This leading manual presents the most recent information and market developments in order to put any installer, engineer or architect in the position to design, select and install a domestic geothermal heat pump system. Internationally respected expert Karl Ochsner presents the reasons to use heat pumps, introduces basic theory and reviews the wide variety of available heat pump models.

Geothermal Energy
Taylor & Francis
1. General Significance of Geochemical Models of Hydrothermal Systems,- 2. Concepts, Classification and Chemistry of Geothermal Systems,- 3.Theory of Chemical Modeling,- 4. Specific Features of Coupled Fluid Flow and Chemical Reaction,- 5. Fossil Hydrothermal Systems,- 6. Recent Hydrothermal Systems,- 7. Reservoir Management.

Geoenergy Modeling II

John Wiley & Sons
In the region comprising Turkey and Greece, people have been using water from geothermal sources for bathing and washing of clothes since ancient times. This region falls within the Alpine-Himalayan orogenic belt and hence is a locus of active volcanism and tectonism and experiences frequent seismic events. This volcanic and tectonic activity has given rise to over 1500 geothermal springs. Its importance was recognized decades ago and the geothermal water is now being utilized for district heating, industrial processing, domestic water supply, balneology and electric power generation. The geothermal potential in this region is large. In Turkey alone it is estimated to be more than 31500 MWt while the proven potential is 4078 MWt. At present 2084 MWt is being utilized for direct applications in Turkey and 135 MWt in

Greece. In Turkey electricity is produced for 166 MW installed capacity, whereas in Greece geothermal energy is presently not used for electricity production despite its potential. This book discusses the geochemical evolution of the thermal waters and thermal gases in terms of the current volcano-tectonic setting and associated geological framework that makes the region very important to the geothermal scientific community. The book explains, in a didactic way, the possible applications, depending on local conditions and scales, and it presents new and stimulating ideas for future developments of this renewable energy source. Additionally, the book discusses the role(s) of possible physicochemical processes in deep hydrothermal systems, the volatile provenance and relative contributions of mantle and crustal components to total volatile inventories. It provides the reader with a thorough understanding of the geothermal systems of this region and identifi es the most suitable solutions for specifi c tasks and needs elsewhere in the world. It is the fi rst time that abundant information and data from this region, obtained from intensive research during the last few decades, is unveiled to the international geothermal community. Thus, an international readership, in the

professional and academic sectors, as well as in key institutions that deal with geothermal energy, will benefit from the knowledge from geothermal research and experiences obtained from the Aegean Region.

Geothermal Energy and Society Academic Press

Since nearly 50 % of Europe's energy demand is in the heating and cooling sector, it is expected that geothermal energy will play an important role in the transition to a decarbonized energy system. However, deep geothermal energy is currently harvested mainly from areas with very favorable geothermal conditions. As these areas are geographically limited, the use of geothermal energy in less favorable regions is essential for unleashing the full potential of geothermal energy, since they make up the majority of the total geothermal potential in Central Europe. Motivated by the growing interest in deep geothermal energy among, e.g., energy companies and communities, this text reviews the state of the art in deep geothermal energy with focus on direct heating in geothermally less favorable regions. It provides an overview of technologies used to generate heat from the deep underground and discusses main technical and non-technical risks associated with deep

geothermal projects. The text addresses readers with an interest in geothermal energy but does not require a background in geoscience or engineering sciences. It is suitable as textbook for Geothermal Energy courses for undergraduate students from different disciplines. Geothermal Reservoir Engineering Springer Science & Business Media Comprehensively covers geothermal energy systems that utilize ground energy in conjunction with heat pumps to provide sustainable heating and cooling The book describes geothermal energy systems that utilize ground energy in conjunction with heat pumps and related technologies to provide heating and cooling. Also discussed are methods to model and assess such systems, as well as means to determine potential environmental impacts of geothermal energy systems and their thermal interaction. The book presents the most up-to-date information in the area. It provides material on a range of topics, from thermodynamic concepts to more advanced discussions of the renewability and sustainability of geothermal energy systems. Numerous applications of such systems are also provided. Geothermal Energy: Sustainable Heating and Cooling Using the Ground takes a research orientated approach to provide

coverage of the state of the art and emerging trends, and includes numerous illustrative examples and case studies. Theory and analysis are emphasized throughout, with detailed descriptions of models available for vertical and horizontal geothermal heat exchangers. Key features: Explains geothermal energy systems that utilize ground energy in conjunction with heat pumps to provide heating and cooling, as well as related technologies such as thermal energy storage. Describes and discusses methods to model and analyze geothermal energy systems, and to determine their potential environmental impacts and thermal interactions. Covers various applications of geothermal energy systems. Takes a research orientated approach to provide coverage of the state of the art and emerging trends. Includes numerous illustrative examples and case studies. The book is key for researchers and practitioners working in geothermal energy, as well as graduate and advanced undergraduate students in departments of mechanical, civil, chemical, energy, environmental, process and industrial engineering. NTA UGC NET/JRF/SET Paper II Geography 28 Solved Papers (2012–2021) Elsevier Advances in

Renewable Energies and Power Technologies Volume 2: Biomass, Fuel Cells, Geothermal Energies, and Smart Grids examines both the theoretical and practical elements of renewable energy sources, covering biomass, fuel cells, geothermal energy, RES, distributed energy, smart grids, and converter control. Dr. Yahyaoui and a team of expert contributors present the most up-to-date information and analysis on renewable energy generation technologies in this comprehensive resource. This volume covers the principles and methods of each technology, an analysis of their implementation, management and optimization, and related economic advantages and limitations, in addition to recent case studies and models of each technology. Advances in Renewable Energies and Power Technologies: Volume 2: Biomass, Fuel Cells, Geothermal Energies, and Smart Grids is a valuable resource for anyone working in renewable energy or wanting to learn more about theoretical and technological aspects of the most recent inventions and research in the field. Offers a comprehensive guide to the most advanced contemporary renewable power generation technologies written by a team of top experts Discusses power control and limitations

of each technology Includes global case studies and models to exemplify the technological possibilities and limitations of each power generation method

Geothermal Power Plants

Springer Nature Hydraulic fracturing has been and continues to be a major techno logical tool in oil and gas recovery, nuclear and other waste disposal, mining and particularly in-situ coal gasification, and, more recently, in geothermal heat recovery, particularly extracting heat from hot dry rock masses. The understanding of the fracture process under the ac tion of pressurized fluid at various temperatures is of fundamental scientific importance, which requires an adequate description of thermomechanical properties of subsurface rock, fluid-solid interaction effects, as well as degradation of the host rock due to temperature gradients introduced by heat extraction. Considerable progress has been made over the past several years in laboratory experiments, analytical and numerical modeling, and in-situ field studies in various aspects of hydraulic fracturing and geothermal energy extraction, by researchers in the United States and Japan and also elsewhere. However, the results have been scattered throughout

the literature. Therefore, the time seemed ripe for bringing together selected researchers from the two countries, as well as observers from other countries, in order to survey the state of the art, exchange scientific information, and establish closer collaboration for further, better coordinated scientific effort in this important area of research and exploration.

Theoretical and Experimental Research on Two-phase Flow in Geothermal Well Bores

Frontiers Media SA
This monograph focuses on the numerical methods needed in the context of developing a reliable simulation tool to promote the use of renewable energy. One very promising source of energy is the heat stored in the Earth's crust, which is harnessed by so-called geothermal facilities. Scientists from fields like geology, geo-engineering, geophysics and especially geomathematics are called upon to help make geothermics a reliable and safe energy production method. One of the challenges they face involves modeling the mechanical stresses at work in a reservoir. The aim of this thesis is to develop a numerical solution scheme by means of which the fluid pressure and rock stresses in a geothermal reservoir

can be determined prior to well drilling and during production. For this purpose, the method should (i) include poroelastic effects, (ii) provide a means of including thermoelastic effects, (iii) be inexpensive in terms of memory and computational power, and (iv) be flexible with regard to the locations of data points. After introducing the basic equations and their relations to more familiar ones (the heat equation, Stokes equations, Cauchy-Navier equation), the “method of fundamental solutions” and its potential value concerning our task are discussed. Based on the properties of the fundamental solutions, theoretical results are established and numerical examples of stress field simulations are presented to assess the method’s performance. The first-ever 3D graphics calculated for these topics, which neither requiring meshing of the domain nor involving a time-stepping scheme, make this a pioneering volume.

Operation and Control of Renewable Energy Systems Springer Nature

Earth's interior contains an enormous amount of heat that can be exploited for carbon-free direct-use or electricity generation. Even though numerous studies have predicted that geothermal power will become an important contributor to the world's energy mix, the use of these

resources is still growing at a notably slow speed compared to other renewable energy alternatives. This thesis uses computational models to explore the technical challenges that two kinds of geothermal resources face to reach full commercialization. In particular, the temporal evolution of heat production of several fractured and closed-loop geothermal reservoirs is investigated. Thermal-hydraulic simulations are conducted for a fractured meso-scale geothermal reservoir in northern New York, USA. The modeling parameters considered here are constrained by empirical data related to lithology, hydrogeology, and thermal behavior measurements collected on site. This work shows how the addition of realistic complexities, that are well-constrained by field data and often disregarded, can significantly improve the thermal performance predictions compared to overly simplified models. Additionally, the results presented here highlight the importance of characterizing subsurface permeability distributions in order to optimize thermal efficiency and devise appropriate reservoir management strategies that extend the lifespan of geothermal reservoirs. To evaluate how closed-loop or advanced geothermal systems (AGS)

compare to alternative ways of extracting geothermal energy, several AGS designs displaying varying reservoir and operating conditions are evaluated to estimate their heat and temperature generating potential. Our findings indicate that the thermal efficiency of AGS is characterized by a considerable exergy loss. Sensitivity analyses show that varying different parameters have slight and moderate improvements on thermal performance, however, AGS designs appear to present multiple technical challenges making them less cost-competitive than both conventional hydrothermal systems and enhanced geothermal systems (EGS). The following key findings summarize the results of these two studies: 1) if well-constrained, computational models are a good tool to assess, manage and intervene geothermal reservoirs to ensure their long-term sustainability, 2) non-uniform permeability can drastically modify fluid flow and heat transport processes in geothermal reservoirs compared to theoretical models that consider homogenous reservoir properties, 3) prospecting adequate subsurface properties is of critical importance to develop geothermal reservoirs, and 4) despite their recent popularity, closed-loop systems are expected to be considerably less productive than other

types of geothermal resources at a similar scale.

Progress in Exploration, Development and Utilization of Geothermal Energy

MDPI
A unique approach to the study of geothermal energy systems This book takes a unique, holistic approach to the interdisciplinary study of geothermal energy systems, combining low, medium, and high temperature applications into a logical order. The emphasis is on the concept that all geothermal projects contain common elements of a "thermal energy reservoir" that must be properly designed and managed. The book is organized into four sections that examine geothermal systems: energy utilization from resource and site characterization; energy harnessing; energy conversion (heat pumps, direct uses, and heat engines); and energy distribution and uses. Examples are provided to highlight fundamental concepts, in addition to more complex system design and simulation. Key features: Companion website containing software tools for application of fundamental principles and solutions to real-world problems. Balance of theory, fundamental principles, and practical application. Interdisciplinary

treatment of the subject matter. Geothermal Heat Pump & Heat Engine Systems: Theory and Practice is a unique textbook for Energy Engineering and Mechanical Engineering students as well as practicing engineers who are involved with low-enthalpy geothermal energy systems.

Geothermal Heat Pumps CRC Press

As nations alike struggle to diversify and secure their power portfolios, geothermal energy, the essentially limitless heat emanating from the earth itself, is being harnessed at an unprecedented rate. For the last 25 years, engineers around the world tasked with taming this raw power have used Geothermal Reservoir Engineering as both a training manual and a professional reference. This long-awaited second edition of Geothermal Reservoir Engineering is a practical guide to the issues and tasks geothermal engineers encounter in the course of their daily jobs. The book focuses particularly on the evaluation of potential sites and provides detailed guidance on the field management of the power plants built on them. With over 100 pages of new material informed by the breakthroughs of the last 25 years, Geothermal Reservoir Engineering remains the only training tool and professional reference dedicated to advising both new and experienced

geothermal reservoir engineers. The only resource available to help geothermal professionals make smart choices in field site selection and reservoir management Practical focus eschews theory and basics-getting right to the heart of the important issues encountered in the field Updates include coverage of advances in EGS (enhanced geothermal systems), well stimulation, well modeling, extensive field histories and preparing data for reservoir simulation Case studies provide cautionary tales and best practices that can only be imparted by a seasoned expert *Low-Temperature Energy Systems with Applications of Renewable Energy* Cuvillier Verlag Rising pollution, climate change and the depletion of fossil fuels are leading many countries to focus on renewable-based energy conversion systems. In particular, recently introduced energy policies are giving high priority to increasing the use of renewable energy sources, the improvement of energy systems' security, the minimization of greenhouse gas effect, and social and economic cohesion. Renewable energies' availability varies during the day and the seasons and so their use must be accurately predicted in conjunction with the management strategies based on load shifting and energy storage. Thus,

in order to reduce the criticalities of this uncertainty, the exploitation of more flexible and stable renewable energies, such as the geothermal one, is necessary. Geothermal energy is an abundant renewable source with significant potential in direct use applications, such as in district heating systems, in indirect use ones to produce electricity, and in cogeneration and polygeneration systems for the combined production of power, heating, and cooling energy. This Special Issue includes geothermal energy utilization and the technologies used for its exploitation considering both the direct and indirect use applications.

Hydraulic Fracturing and Geothermal Energy

Springer Science & Business Media

A modern and unique perspective on solar and geothermaltechnologies for heating and cooling buildings This book will have a broad appeal reaching practising engineersin the industry as well as students. With introductory sections foreach technology described, material includes chapters on:geothermal energy use for the heating and cooling of buildings; achapter on electrically driven heat pumps/chillers; material onnight radiative cooling, photovoltaic thermal collectors,temperature

modelling and thin film photovoltaicmodelling. Includes general introductory sections for each technology withmarket potential and applications Covers an increasingly important component of energycourses Considers a broad range of alternative renewable energysupplies relevant to the building sector, such as geothermal energywith heat pump With a special focus on solar cooling, provides detailedphysical models of all technologies and example calculations Unique in covering the fundamentals of meteorologicalmodellin g

Reactive Transport Modeling John Wiley & Sons

This book addresses the societal aspects of harnessing geothermal resources for different uses, such as power production, heating and cooling. It introduces a theoretical framework for a social scientific approach to the field, and presents a preliminary collection of empirical case studies on geothermal energy and society from across the world. By providing a conceptual and methodological framework to the study of geothermal energy and societies, it brings together information and analyses in the field that to date have been sparse and fragmented. The contributors explore the diverse aspects of the relationship between the harnessing of

geothermal resources and the societies and local communities in which these developments take place. After introducing geothermal technologies, renewable energy concepts as well as their social and policy context and the regulative and environmental aspects of geothermal energy, the book analyzes and discusses twelve global case studies, and compares the social engagement tools applied with those used in other sectors. Of interest to researchers from a range of disciplines who wish to explore the issues surrounding energy and society, it is also a valuable resource for geothermal experts and postgraduate students wish to study the field in greater detail.

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