This book deals with issues of fluid flow and solute transport in complex geologic environments under uncertainty. The resolution of such issues is important for the rational management of water resources, the preservation of subsurface water quality, the optimization of irrigation and drainage efficiency, the safe and economic extraction of subsurface mineral and energy resources, and the subsurface storage of energy and wastes. Over the last two decades, it has become common to describe the spatial variability of geologic medium flow and transport properties using methods of spatial (or geo-) statistics. According to the geostatistical philosophy, these properties constitute spatially correlated random fields. As medium properties are random, the equations that govern subsurface flow and transport are stochastic.

This volume describes the most recent advances in stochastic modeling. It takes stock of mathematical and computational solutions obtained for stochastic subsurface flow and transport equations, and their application to experimental field data, over the last two decades. The book also attempts to identify corresponding future research needs. This volume is based on the second Kovacs Colloquium organised by the International Hydrological Programme (UNESCO) and the International Association of Hydrological sciences. Fifteen leading scientists with international reputations review the latest developments in this area of hydrological research.

The book is a valuable reference work for graduate students, research workers and professionals in government and public institutions, interested in hydrology, environmental issues, soil physics, petroleum engineering, geological engineering and applied mathematics.

Subsurface Flow and Transport: A Stochastic Approach

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Preface

This book contains the refereed and edited proceedings of the Second IHP/IAHS George Kovacs Colloquium on Subsurface Flow and Transport: The Stochastic Approach, held in Paris, France, during January 26–30, 1995. The Colloquium was convened by Professors Gedeon Dagan and Shlomo P. Neuman under the auspices of UNESCO's Division of Water Sciences as part of its International Hydrological Programme (IHP), and the International Association of Hydrological Sciences (IAHS).

The book is devoted to issues of fluid flow and solute transport in complex geologic environments under uncertainty. The resolution of such issues is important for the rational management of water resources, the preservation of subsurface quality, the optimization of irrigation and drainage efficiency, the safe and economic extraction of subsurface mineral and energy resources, and the subsurface storage of energy and wastes. Over the last two decades, it has become common to describe the spatial variability of geologic medium flow and transport properties using methods of statistical continuum theory (or geostatistics). According to the geostatistical philosophy, these properties constitute spatially correlated random fields. As medium properties are random, the equations that govern subsurface flow and transport are stochastic. This book takes stock of mathematical and computational solutions obtained for stochastic subsurface flow and transport equations, and their application to experimental field data over the last two decades. The book also attempts to identify corresponding future research needs.

The book contains invited articles on selected topics by 15 leading experts in the emerging field of stochastic subsurface hydrology. All 15 authors have made seminal contributions to this field during its early formative years. The book opens with a broad retrospective on stochastic modeling of subsurface fluid flow and solute transport by G. Dagan. It then proceeds with three papers devoted to the characterization and estimation of subsurface medium properties that control flow and transport. The paper by M. P. Anderson emphasizes geological considerations in the characterization of subsurface heterogeneity that by J. Samper describes methods of geostatistical inference while J. Carrera addresses practical and theoretical aspects of parameter estimation by inversion (the so-called inverse problem). Flow modeling and aquifer management are discussed in three articles by P K. Kitanidis, R. E. Ewing, and S. M. Gorelick. The first of these three articles concerns computer modeling of flow in randomly heterogeneous porous media; the second surveys and assesses the state of the art in numerical simulation of multiphase flows in such media; and the third shows how to incorporate uncertainty into computer models of aquifer management. Four articles are devoted to solute transport in randomly hetrogeneous porous media. Y. Rubin presents an overview of purely adjective transport; V. Cvetkovic extends the treatment to reactive solutes; J. H. Cushman highlights nonlocal effects on transport; and L. W. Gelhar explains how stochastic transport theories have been used in the interpretation of field-scale tracer tests. The difficult topic of flow and transport in fractured rocks is tackled in a specialty paper by J. C. S. Long. It is followed by two papers on multiphase phenomena: one by D. Russo on stochastic analysis of transport in partially saturated heterogeneous soils, and the other by J. C. Parker on field-scale modeling of multiphase flow and transport. The book closes with a view to the future by S. P. Neuman.

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