

BOOK REVIEWS

Subsurface Flow and Transport: A Stochastic Approach (1997) Gedeon, D. and Neuman, P.S. (eds) ISBN 0 521 57257 6 Cambridge University Press, Cambridge £70

My last serious contact with the type of work described in this book was some decade ago. I was, therefore, interested to learn what progress had been made in the intervening period. Rather predictably, some of the old certainties about kriging being a panacea for all problems of heterogeneity in subsurface materials have broken down, although not as much as might have been expected. Equally, the impact of fractal and chaos theory is more muted than I anticipated. As a result, I found much of the book's subject matter quite recognisable.

The articles in the book are based on papers presented at the second George Kovacs Colloquium, held in Paris in 1995. For those who were not privileged to participate in the colloquium, this is an irrelevance, particularly since no details of any discussions are included. The book must stand or fall by the quality and relevance of the articles included, both individually and collectively. Individually, each contribution is authoritative and would almost certainly be publishable in journals with the highest standards of refereeing. Collectively, they stand together surprisingly well by comparison with most collections of colloquium papers. This may be a sign that the papers were invited and that the organisers took the trouble to ensure that complementary subjects were covered. This does not imply, however, that there is no overlap between the subject matter of different papers nor that there are no gaps. There is plenty of overlap between nine of the first ten articles, all theoretical treatments of flow and solute transport in heterogeneous porous media. Some of the overlap is a result of the authors' attempts to make each article stand alone, whilst covering only a part of the subject. More of it may well be a result of the narrow geographical spread of the parent institutions of the authors (and hence limited variety of approach). In the book as a whole, 18 of the 24 authors are based in the USA, 3 in Spain, 2 in Israel and one in Sweden. Close connections between several authors in different countries are well known and signalled in the reference lists. A major surprise, especially for a symposium held in Paris, is that none of the well-known French experts in geostatistics is represented.

Ten of the contributions present different facets of a highly mathematically and theoretically sophisticated approach to the subject, relying on the availability of tremendous amounts of computing power and, seemingly,

divorced from the real world of recognisable geological units and the need to produce solutions amenable to comparison with experimental observation. A worrying trend emerging is the substitution of real observations with solutions from a supposedly 'correct' numerical model, with which another model may be compared. The rest of the book is more practical and, to my mind, much more exciting. Mary P Anderson describes how traditional geological mapping may be incorporated into the pictures of the more idealised formations with which most of the models deal. Lynn Gelhar synthesises brilliantly a wide range of experimental and theoretical work from several contaminated aquifers; this was, for me, the high point of the book. Jane Long *et al.* link rock mechanics and hydrology well. Jack Parker's excellent review of oil-water-air systems, albeit with only a tenuous link to stochastic models, should be a standard reference for many years. Finally, Shlomo Neuman lays bare many of the weaknesses in our understanding from philosophical, theoretical and practical points of view.

Apart from making a good (although rather narrow) choice of papers, the editors appear to have adopted a rather hands-off approach to their task. The introductory article by Dagan could well have incorporated a route map through the book, but studiously avoids being more helpful to the reader than vague references to 'another chapter' which deals with a topic in detail. Similarly, there are remarkably few cross-references within the rest of the articles. Unnecessary jargon and convoluted English abound in some articles, limiting the accessibility of these to many potential readers not versed in the finer points of mathematics or the English language. The prevalence of typographical errors does not help.

The importance of the subject matter of the book is not in doubt. Much of the work described has been funded by radioactive waste disposal programmes in various countries and the clean up of contaminated aquifers is an important application of much of the work. Unfortunately, the highly theoretical nature of the treatment of the subject matter, which in some cases uses mathematics to conceal, rather than illuminate issues, is unlikely to produce a widening of understanding in dealing with such problems. This must be counted an opportunity missed, since, as Gelhar states: 'While researchers debate theoretical minutiae, billions of dollars are being spent—some would say wasted—trying to clean up serious contamination and to protect aquifers from future degradation'.

The book can be recommended to those with graduate-level mathematical and statistical skills as a reference to the latest theoretical modelling techniques in subsurface hydrology. Also to those who wish to link modelling and

experimental work in this area, provided they are not deterred by the mathematics or the book's price. This is, unfortunately, a small audience and excludes most of those who will be expected to make decisions and the practitioners who will put them into effect.

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Karst Waters and Environmental Impacts (1997) Gunay, G. and Johnson, A.I. (eds.) ISBN 90 5410 8584 Balkema Rotterdam 525p Price 225NG

This book comprises 65 papers selected from the proceedings of the 10-day international symposium and field seminar of the same name held in Antalya, Turkey in September 1995. The symposium was organised by the International Research and Application Centre for Karst Water Resources (UKAM), Hacettepe University of Ankara, Turkey. A broad spectrum of topics important to karst environmental issues and hydrology was covered.

The symposium promoted exchange of knowledge between developed and developing countries and the wide representation of countries at the meeting showed that this was achieved, although the English language in some of the papers was unusual. In addition, practical case histories from all over the world were presented. Thus, politicians and decision makers might become informed of typical problems encountered in karst environments, of the potential impact of certain decisions and of the solutions to managing these situations in different parts of the world.

The book is divided into 11 chapters with from 2 to 12 papers per chapter.

Chapter 1, 'Legal Aspects and Regulations', presents examples typical of water over-exploitation resulting in drawdown over large areas, increased pollution and subsidence risks, etc. These characterise the impacts and illustrate that even highly technical studies and scientific knowledge of karst systems may not lead to correct management if local politicians and decision makers are not well informed.

Chapter 2, 'Environmental Impacts of Karst', concentrates on dry and arid regions which are important for three major reasons:

- 1) Low recharge results in aquifers that are more sensitive to over-exploitation and/or pollution;
- 2) population increases are higher than in well developed countries; and
- 3) awareness of environmental problems is lower and so improvements are much more difficult to achieve.

Many of the papers identify problems, such as those of water quantity and quality but, perhaps because of lack of adequate financial resources, few present results of successful remediation.

Chapter 3, 'Pollution Control and Karst Water Protection', presents examples of pollution, followed by proposed 'protection zones' designed to improve water quality in future. Difficulties of delineating effective and meaningful ground water protection zones in karst areas are pointed out in each paper but only in one was a protection assessment approach presented. Characterising the unique and important parameters associated with karst aquifers is stated to be more reliable than standard hydrogeological modelling for assessing the vulnerability of karst waters.

Chapter 4, 'Transport Processes', concerns tracer experiments and contains quantitative analyses, tracer comparisons and interesting experimental results. The physical meaning of hydrogeological parameter values obtained by fitting data to input-output models is difficult to assess. Other methods such as gas surveys are proposed as mapping tools for locating heterogeneity (fractures) in land drained by karst rock. An interesting approach showed transfer between a swallow-hole and a cave 100m below and offered new insights into unsaturated zone behaviour.

Chapter 5, 'Hydrochemistry', comprises four papers which address the statistical analysis of hydrochemical data. The chemical behaviours of 'deep phreatic karst systems' and 'shallow or gravity systems' are distinguished by correlation methods. The strong dependence of water chemistry on system discharge is also demonstrated. Nevertheless, as in the past, hydrochemical observations in karst are interpreted using purely statistical approaches unlinked to the physics of the processes. Filling this gap in knowledge is a major scientific and technical challenge for the next decade.

Chapter 6, 'Environmental Isotopes in Karst', presents interpretations based on simplified physical models; they appear to be oversimplified as they seldom lead to realistic results. For example, residence times corresponding to base flow, the slowest component of flow, in some Slovenian springs are estimated by such a model to be of the order of months. Yet, for karst waters in other areas the mean ages obtained by dating range between 3 and 1000 years. Are Slovenian karsts so different from German, Turkish or Greek ones? These papers present a range of values but either the models or the age dating interpretations must be improved to give consistent results.

Chapter 7, 'Karst Morphology and Palaeoenvironment', has two papers on interpretation of cave morphology and sediments. Another paper, on cave speleogenesis in gypsum in the Ukraine provides new insights into Ukrainian artesian aquifers. Yet another paper stresses the importance of algae within the deposition of tuffs. The last paper

shows how geomorphic conditions may be used to optimise the development of the water resources of a karst aquifer in China.

Chapter 8, 'Modelling and Flow Systems' has 11 papers and represents the major theme of the book. One paper addresses mathematical concepts and shows the limits of a well-known conceptual model (Schoeller 1967). Three papers demonstrate the large spatial heterogeneity of physical parameters within karst aquifers. Such observations, coupled with modelling results, show that piezometric maps and water levels cannot be used to interpret, reliably, the hydraulic conditions in karst systems. The problem of modelling karst can be addressed more readily by using the double continuum approach which requires less detail of the distribution of the physical parameters. Although more global, this approach can produce consistent results as one of the papers shows. Most of the other papers deal with 'black-box' models based on mathematical functions transforming input time-series into output. These models are easier to fit to real data and are useful for time predictions. However, they do not provide much insight into the physical behaviour of the system. Finally, one paper presents a conceptual model that attributes the behaviour of an intermittent spring in the USA to the temporary plugging of a conduit.

Chapter 9, 'Engineering Problems in Karst', looks at spectacular problems of leaks related to dams in karst areas or to huge dewatering projects for the mining industry.

Chapter 10, 'Research Methods', considers three approaches: geophysics, sampling in karst conduits within the aquifer and inference of aquifer structure from global (spring) response (e.g. temperature). Interpretation of geophysical methods may be difficult and is often limited, so that many methods have to be used simultaneously or in connection with other hydrogeological methods to provide adequate and informative interpretation. Where possible, direct observations within the karst conduits provide precise knowledge about structure and behaviour. In the case presented, ^{222}Rn and ^{18}O analyses allowed the author to quantify and locate the water exchange region between a surface river and a spring. Unfortunately, conduits can rarely be entered. As illustrated, the classical approach is to infer or evaluate the structure and the behaviour of karst systems from the response observed at a spring. The paper provides a potentially useful new tool to interpret temperature signals of karst springs which, to date, have been interpreted without any exact knowledge of the physical context.

Chapter 11, 'Regional studies', addresses many classifications of karst aquifers in different parts of the world but mostly around the Mediterranean. These classifications are often based on the lithological and structural situation of the systems and also on spring discharge analysis (time series analyses) complemented with water chemistry. Two studies illustrate new trends: 1) Applications of variograms, Kriging and principal component analyses to spa-

tial data sets to assess the spatial distribution of chemical parameters and uncertainties of the resulting maps; 2) prediction of karst systems behaviours in response to future predicted climate changes around the Black Sea.

To a karst hydrologist, this is a useful reference book. It summarises the state of the art in Europe and most areas of the world concerned with environmental considerations in such aquifers and flow systems. It illustrates that, for the most part, the ongoing research is still highly qualitative and descriptive. It indicates the focus of current modelling as well as investigations of network development processes. It is an excellent presentation of papers by knowledgeable workers in the field; it illustrates the progression from simple observations to more focused technical and scientific studies of the karst environment. Such an improved understanding will minimise the effort necessary to convince politicians and law and decision makers of the necessity to address the inherent environmental issues associated with managing karst aquifer resources effectively.

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Operational Water Management (1997). Refsgaard, J.C. and Karlis, E.A. (eds), Balkema, Rotterdam

The book is the published proceedings of the European Water Resources Association (EWRA) Conference held in Copenhagen on 3-6th September 1997. The conference was organised by the BWRA, the Danish Water Resources Committee and the Geological Survey of Denmark and Greenland. The book presents almost seventy reviewed and edited papers which were presented at the conference.

Disappointingly, though not surprisingly, there were few papers produced by practitioners in the water industry or by consultants. However, whilst the majority of papers were written by academics, the authors in the main attempted to cross the boundary from theoretical analysis into practical applications with the use of case studies. That said, in most cases, it is difficult for a practitioner to judge from the information presented whether the analytical tools used had actually been used in anger within a real world operating environment.

The editors are to be congratulated for taking a broad definition of water management, so often in the UK constrained to water quantity issues. The breadth of papers covers a range including the classics of how to operate a water resources system and how to use a rainfall runoff model in flood forecasting. Less familiar to most readers would be the challenges associated with operating

wastewater treatment works and urban storm drainage management. From that point of view, the book gives readers the opportunity to dip into these topics at an understandable level without having to consult a specialised publication. New technology plays its part also with much coverage of GIS and other recent advances. However, the costs and benefits associated with implementing such approaches was not always clear.

The book is well edited and diagrams, screen images and typeface are generally very easy to assimilate.

All in all, the book is well worth a browse, but on loan from a library rather than an individual purchase.

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Financial Aspects of Water Management (1997). van Hofvegen, P. and Schultz, B. (eds), Balkema, Rotterdam.

The book is the published proceedings of the 3rd Netherlands National ICID (International Commission on Irrigation and Drainage) Day on the theme of financial aspects of water management.

There are nine main papers in the publication. They range from a generic introduction to financial matters in the water industry to specific examples of how water management is financed in the Netherlands, Argentina and Asia. Irrigation dominates, though there are papers on urban water use. There is a paper which explores the challenges and opportunities regarding the financial management of water resources that cross national or state boundaries and the potential for financial and political conflict that this can generate.

The book has less than 120 pages and as such is limited in its scope. Opportunities to consider the applicability of case studies in a wider context are therefore limited. This is not helped because the financial aspects of the management of water are so clearly driven by the organisational and political arrangements in the country. This makes generalisation difficult, though themes such as consumers willingness to pay do come through in a number of the papers.

Consideration of the financing of new works and the need for economic benefit/cost assessment are not considered in any depth. This is a big gap when it is recognised that the major challenge facing many managers in the industry is the valuation of intangible costs and benefits, be it customer satisfaction or environmental quality. Another major omission is the lack of discussion of the opportunities to use pricing mechanisms to modify customer use.

Overall, it is not clear who the target audience is. A specialist in financial matters will need more depth than pro-

vided here. Someone wishing for an appreciation of financial matters would need more breadth to appreciate the key issues facing the industry today, worldwide.

Overall conclusion: one to leave on the library shelf.

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Riparian landscapes (1996). Malanson, G.P.
ISBN 0-521-566835 Cambridge University Press:
Cambridge, UK, pp. 306, £20.95.

The riparian zone, that part of the catchment where the river itself exerts a strong influence on ecological processes, is complex and heterogeneous yet structured. Landscape ecology, as a discipline that strives to escape from concentration on simplified and bounded ecosystems and to introduce a spatial dimension, is a promising approach to the understanding of the physical, chemical and biological functioning of the riparian zone. The author argues convincingly and at length not only for the adoption of the spatial emphasis, but also for the consideration of the topological relationships between landscape elements. This is a book about interactions, between hydrology, geomorphology and ecology, and between the processes of flow, sediment dynamics and the development of plant communities.

The opening chapter sets out the principles of landscape ecology, its history and fundamental concepts. Landscape ecology, like many other new subject areas, has been forced to adopt a borrowed terminology, and to modify meaning to suit its own specific needs. On first reading, this book appears to be populated by words whose meaning, undefined in the first instance, has to adapt and evolve in the mind of the reader. That this is the case, not only with words, but also with the central concepts of the discipline, is a serious fault, and one that should be addressed in future editions. For instance, the process of landscape reproduction, the resource spiralling concept and the distinctions between feedbacks and dialectical relationships are never properly introduced, though they will be the reader's constant companions throughout.

The second chapter deals with landscape ecology as it applies to the riparian zone, considered as a barrier separating highland areas, as a conduit for water, sediment and dissolved substances with a complex internal system of detention and cycling, and as a corridor for the passage of species. The author introduces spatial factors such as shape, width and configuration, and the significant tendency of the linear riparian zone to break up, under the influence of channel migration and human interference, into patches whose mutual isolation may have considerable ecological significance. Non-equilibrium conditions, par-

ticularly meander migration, which define some of the tesserae, the smallest units of the landscape, develop into a persistent theme later in the book.

Chapter 3 is about the structure of the landscape, and the role of the riparian zone within it. The author's approach to this broad area is to consider river landscapes in various ecoregions, from the taiga of Canada and Scandinavia to the tropical forests of Amazonia. For each river landscape type, he evaluates the relative significance of factors such as lateral water movement, flooding and geomorphological processes. Results indicating significant longitudinal gradients along the riparian corridor, as a consequence of history, climate and altitude, are presented as a reminder of the danger of over-simplification. However, this chapter gives the first indication of the distinction between the "American School" and the "European School" of landscape ecology: all of the systems described here are controlled by natural processes, and there is no consideration of the long history of human influence that has modified riparian zones in both Europe and the US, not only with river management but also with grazing and cultivation. The most highly valued habitats on British floodplains, for instance, are not forests and scrub, but meadows and fens, maintained through historical times by traditional practices.

In Chapter 4, internal structure is considered, especially the effects on the vegetation community of disturbance at various scales. Processes of erosion and sedimentation expose fresh sites for colonisation, soil moisture and the water table influence the composition of the community, and hydraulic structures (from beaver ponds up to engineered dams) propagate their effects upstream and downstream.

Central to landscape ecology are the flows of material (for instance water, sediment, carbon and nutrients), energy and species (viewed here as information). Flow processes are described in Chapters 5 (Cascades of material and energy) and 6 (Species dynamics). At this point the

author introduces the concept of the spiralling of resources, in which resource cycles are superposed on an overall downstream drift. Reduction of the drift rate, described as a tightening of the spirals (helices?), is generally a positive value of the riparian zone. Again, the reader is challenged to arrive at a definition of the concept, either from the context or by consulting the sources in the bibliography.

Finally, Chapter 7 (Organising the landscape) pulls together the various themes and deals with the present status of, and possible future expansion of, modelling of riparian zones. The author discusses the possibilities of combined hydrological/geomorphological/ecological models based on the advanced spatially-distributed models (e.g. SHE) designed for hydrology. Hydrologist readers may well experience a glow of pride at this point, though this reviewer suspects that the problems of quantification, calibration and validation of a landscape supermodel may prove insoluble.

Landscape ecology is a developing science – its eponymous journal is only eleven years old – and its output is more descriptive than quantitative, let alone predictive. The author has done an excellent job in collecting together a wealth of ecological, biogeographical and geomorphological material and presenting it in a landscape-ecological light. If only he had pitched the text at general readers from the environmental sciences, they could have gained considerably more from a book that was richer in clear definitions and diagrams. On the other hand, it would be difficult to find a book in this area with a fuller account of the literature and a more comprehensive bibliography. Thus, this volume will find a wide and appreciative readership among those responsible for the management of the wider countryside as well as river corridors and surface water resources.

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Corrigenda:

The Editor regrets that incorrect figures were printed on pages 862 and 866 of *Hydrology and Earth System Sciences* 1(4). These pages are reprinted here on pages 146 and 147 with the correct figures. It is suggested that subscribers annotate the appropriate pages of *HESS* 1(4) with the reference to these Corrigenda.

CONCENTRATION PROFILES

Figure 4 shows concentration profiles at 12.5 days after solute application. The solute concentration profile does not vary much along the transect indicating relatively homogeneous solute flow for the similar field case. For the other three cases, the concentration profiles vary considerably along the transect and reflect the water flow patterns shown in Fig. 3. Solute transport is mainly vertical for the crust ring case with unimodal depth profiles of concentrations at nearly all locations along the transect. For the Kopecky ring and large column cases, the concentration profiles are very irregular. Due to considerable horizontal solute flow, bi- or multi-modal depth profiles are observed at several locations along a transect. Owing to the small

horizontal correlation of $\ln(\alpha_K)$ ($\gamma_l = 0.1m$), solute concentrations vary over a small horizontal cross-section. This is in agreement with the conclusions drawn by Jacques *et al.* (1997c) who found that the major part of the solute flow heterogeneity observed at the field-scale is present within the 0.5m by 0.1m sampling area of a TDR probe.

BTCS OF \hat{C}^r AND \hat{C}^f

In Fig. 5, \hat{C}^r (Eqn. 18) and \hat{C}^f (Eqn. 19) BTCs calculated at 1.0m below the input surface and normalised to C_0T_0 , with T_0 the amount of water-filled pore volumes added during the application time t_0 , are plotted as a function of the number of water-filled pore volumes, $T = qt/z <\theta>$. The dispersion and the difference between BTCs for \hat{C}^r

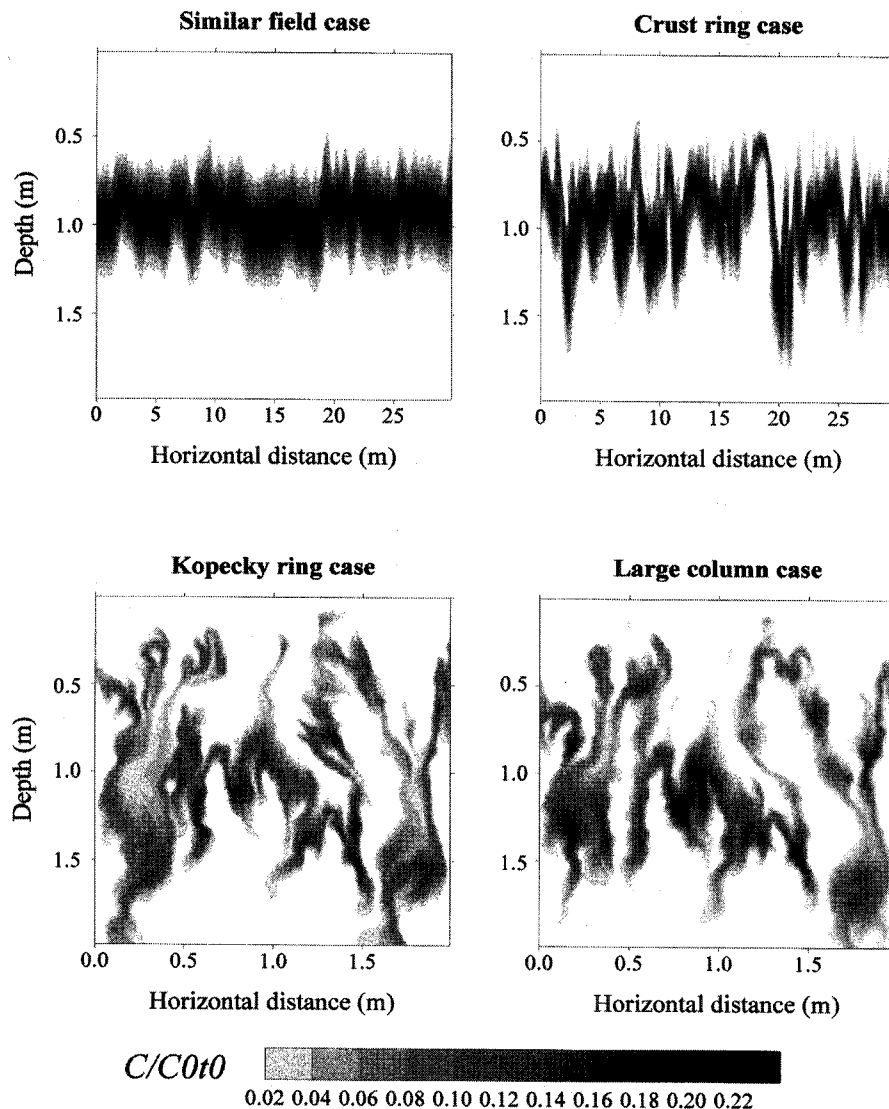


Fig. 4. Concentration profiles simulated for steady state unsaturated flow (infiltration rate = 2.8 cm d⁻¹) 12.5 d after the start of solute application. Concentrations are normalised by C_0t_0 , with C_0 the concentration of the input solution and t_0 the solute application time.

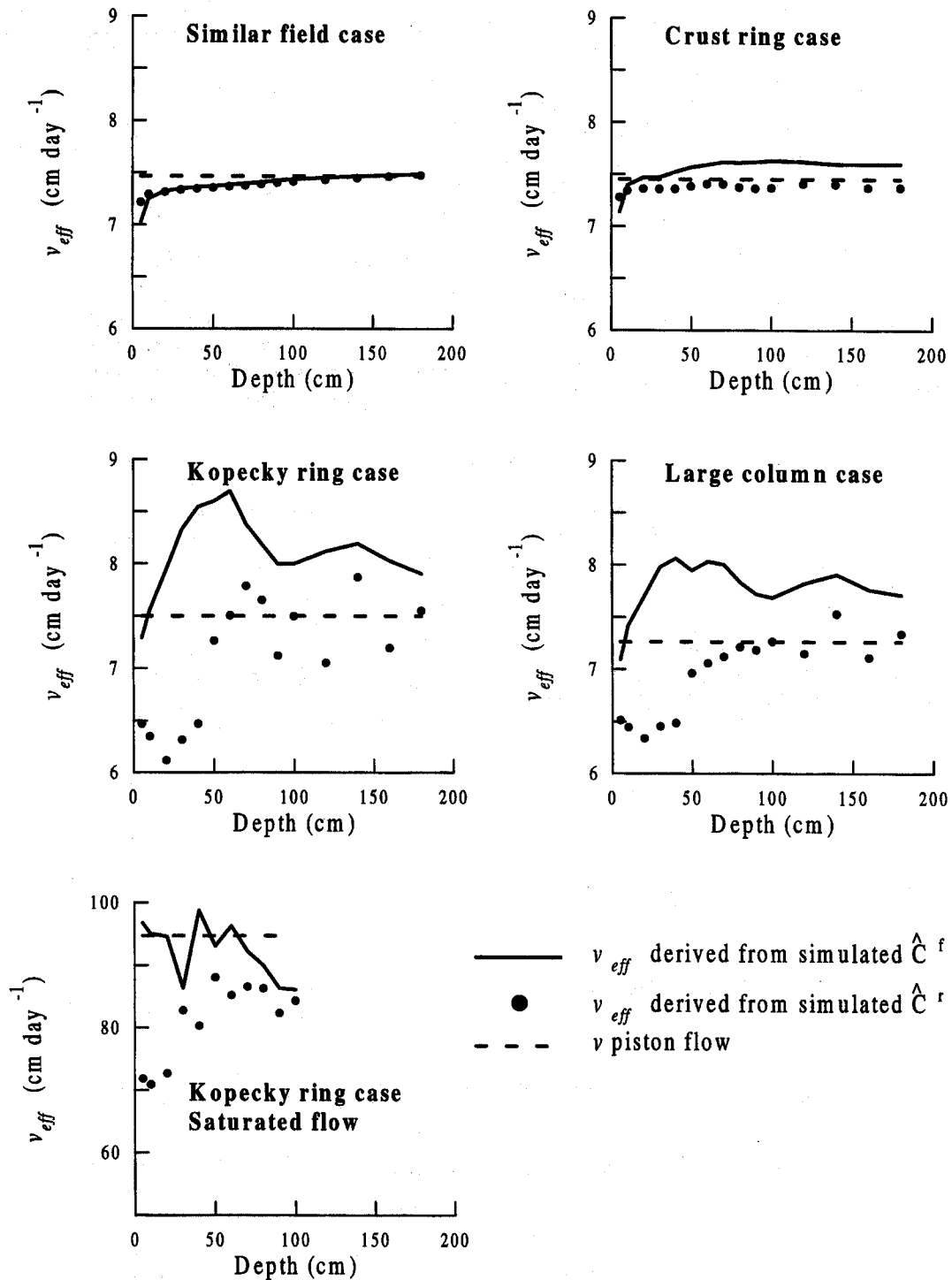


Fig. 7. Effective average particle velocities, v_{eff} , derived from simulated BTCs of field-scale volume averaged and flux averaged concentrations and the piston flow particle velocities, $v = \langle J_{w2} \rangle / \langle \theta \rangle$.

compared to $\langle J_{w2} \rangle / \langle \theta \rangle$. This comparison suggests that for larger $\sigma^2 \ln(\alpha_K)$ and stochastic-convective transport, solutes are leached out faster than under piston-flow conditions which indicates 'preferential' flow. However, when v_{eff} is calculated from the time moments of \hat{C}^f BTCs (Jury

and Sposito, 1985), v_{eff} is nearly identical to $\langle J_{w2} \rangle / \langle \theta \rangle$ (results not shown). Therefore, the larger v_{eff} obtained from fitting the 1-D CDE to the simulated BTCs are due to a lack-of-fit. Simulated BTCs are more skewed than the fitted ones which underestimate simulated solute concen-

