



Editorial

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1 Introduction

On the 31st of March 2017, with considerable international audience, the “First Stuttgart Porous Medium Science Slam” took place on the occasion of the 60th birthday of Prof. Rainer Helmig. The numerous short contributions ranging from purely scientific to deeply personal all had in common the deep and sincere appreciation of the person Rainer Helmig. Taking into account the enormous scientific standing of Rainer Helmig, the editors found it appropriate to elucidate his scientific contributions, in particular by gathering various papers of colleagues, who are closely related to him, for this special issue.

Numerical modeling of multiphase flow processes in porous media is, for many of his peers, inherently associated with the name of Rainer Helmig. Since the mid-1990s, he has been one of the most active and most visible members of this scientific community. He has shaped the field of modeling and simulation of complex processes in porous media and their applications in all possible aspects: in advancing high-end research based on the development of one of the leading legacy code family, and published in numerous papers in international journals, in the education of young scientists, in the organization of research clusters, and in fostering and even founding of research organizations.

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The enormous scientific career was not to be foreseen for young Rainer: He originated from a working class family, born in the industrial western part of Hamm in Westphalia in 1957, and grew up in a region and time when school education became the perspective of a better life. But his school career seemed to end before it had started. Rainer had to leave grammar school (the German Gymnasium) only after a few months because of a serious disease, and once recovered, he returned to what seemed to be appropriate for him from his family background and finished his education as an architectural draftsman. But he went on: finally, in 1977, he reached the “Fachabitur” giving him the allowance to study (technical subjects). He graduated in Civil Engineering first at the University of Applied Sciences in Münster in 1981 and then at the University of Hannover in 1986. He became a research assistant at the Institute of Fluid Mechanics under the supervision of Werner Zielke and in 1992 he received his doctoral degree in Hannover. Now, at already 35 years, his scientific career could begin. And how it began: he went to Stuttgart to the Institute of Hydraulic Engineering, led at that time by Helmut Kobus, got his habilitation there in 1996 and soon became full professor at the Institute for Computer Applications in Civil Engineering at the Technical University Braunschweig. Eventually, in the year 2000, he returned as full professor to his former institute in Stuttgart, which has been renamed in 2012 into “Institute for Modelling Hydraulic and Environmental Systems.” In Stuttgart, his international recognition has grown dramatically since then, reflected in awards and keynote lectures, way too many to be mentioned here. In the following, we give only a few examples.

In 1995, Rainer Helmig was awarded for his doctoral thesis on modeling fractured porous media with the “Dresden Groundwater Research Prize” (Dresden Grundwasserforschungspreis), a well-respected prize for young researchers in the German groundwater community.

In 2015, he was appointed Darcy Lecturer by the US National Groundwater Association and delivered 68 talks on four continents. He gave 19 invited keynote and plenary lectures at international conferences during the

last five years. He is member of the Heidelberg Academy of Sciences and of the National Academy of Science and Engineering acadtech. Maybe one of the keys for his enormous success can be found in his boundless willingness in sharing his knowledge and his enthusiasm. He has been the principal supervisor of 40 doctoral students and fostered 7 habilitations, and in total served in more than 100 doctoral committees in a wide range of countries. He initiated the graduate schools in the International Research Training Group “Non-linearities and Upscaling in Porous Media” (NUPUS) as well as within the Collaborative Research Center “Interface-Driven Multi-Field Processes in Porous Media-Flow, Transport and Deformation” (SFB 1313).

Various highly visible research networks came to existence and life by his major contributions: not only the aforementioned NUPUS and SFB 1313, with their predecessor SFB 404, “Multifield Problems in Continuum Mechanics,” where he served and serves as a spokesperson or vice spokesperson, respectively, but also as one of the shaping figures of the Cluster of Excellence “Simulation Technology” at the University of Stuttgart. SimTech has just recently successfully acquired a new funding phase with a focus on “Data-integrated Simulation Science.”

Rainer Helmig also served the scientific community far beyond of Stuttgart and Germany. We mention additionally his membership in various editorial boards in international journals, and his always very active membership in a wide range of organizations and scientific committees, often as head, including Gordon Research Conferences, Computational Methods in Water Resources, and in particular his eminent role in the founding of the International Society for Porous Media (INTERPORE), for which he served as first president.

Finally, let us come to the core of everything, Rainer Helmig’s scientific achievements. He is a representative of a modern type of engineering, concentrating on simulations based on modern methods and models, with a strong appreciation for their rigorous mathematical foundations, and contributing to all of the mentioned aspects. At least in Germany, he has been a pioneer in this way, serving as a role model for many young engineers and scientists. By transferring and extending a level of modeling and simulation, until then only established in petroleum engineering, to the geosciences in general and to environmental science in particular, and recently also to the life sciences, he gave a new shape to these fields, not only in Germany. Still a landmark is his 1997 Springer monograph *Multiphase Flow and Transport Processes in the Subsurface* [1], originating from his habilitation work. In his enormous contribution of about 200 publications written together with 150 co-authors, various continuing threads can be found.

Such an extended research work makes it very difficult to choose which of Rainer’s publications define him as a scientist, and are most inspiring for other researchers. Such a list should, in any case, start with his contribution to multiphase flow in fractured porous media, where he successfully advocated the use of mixed-dimensional approaches (see, e.g., [2]). Quite early, Rainer was aware of possible deficiencies of the classical upscaled multiphase flow model with the static saturation-capillary pressure concept (see, e.g., [3]). As already mentioned, the backbone of all investigations is the development of a widely recognized legacy code (DuMux, and until 2007, the predecessor MUFTE) by his working group (see, e.g., [4]). In more recent years, the general theme of multiscale compositional multiphase flow got extended to the investigation of the coupling of subsurface flows and free flows, also in the compositional and multiphase context (see, e.g., [5]). As seen, many of the works aim, in the sense of a goal-oriented modeling, at the coupling of models of different complexities, with respect not only to spatial scale and dimension but also to phases or processes considered, etc. A general outline of this concept may be found in [6]. Finally, as a different kind of contribution, we mention [7]. This article presents a comprehensive benchmark study including the comparison of a number of mathematical and numerical models applied to characteristic scenarios of carbon dioxide storage in geologic formations. This paper has been distinguished with the *highly cited* predicate in the Web of Science database.

Acknowledgements The guest editors would like to thank all authors who have contributed to this special issue. Addressing diverse aspects in the mathematical modeling and numerical simulation of various processes in porous media, these papers are reflecting a part of the broad spectrum of topics covered in Rainer Helmig’s research work.

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