

Foreword

NUPUS: Porous Media Research Has Got a Brand Name

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1 Non-linearities and Upscaling in Porous Media

Flow and transport in porous media is a field of research that covers a huge range of engineering applications, involves researchers from very different disciplines, and raises fundamental questions of different kinds. Many of these research questions can be summarized into two major categories: non-linearities and upscaling.

Non-linearities are a particularly dominant feature of multiphase flow systems and arise from strongly nonlinear constitutive relations for basic hydraulic properties that characterize the interaction between porous media and fluids. Environmental, technical, biological, and geomechanical porous media applications reveal a whole variety of characteristic spatial and temporal scales as well as heterogeneities. This issue of scales and heterogeneities leaves upscaling as an inherent task to any porous media modeling approach where the processes are not resolved on the smallest scales.

An interdisciplinary approach to tackle these challenges is very important. This provides the required basis for communication and exchange between disciplines and enables a more comprehensive treatment of the problems.

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2 NUPUS

Research Programme: Non-linearities and Upscaling in PoroUS Media has become **NUPUS** and with that an established brand name for internationally highly recognized research in this field.

NUPUS started in January 2007 as an International Research Training Group at the University of Stuttgart, funded until December 2015 by the German Research Foundation (DFG, GRK 1398), and partnered by Dutch universities in Delft, Eindhoven, Utrecht, and Wageningen as well as the University of Bergen (Norway). The Dutch and the Norwegian partners are funded by the Netherlands Organisation for Scientific Research (NWO) and the Research Council of Norway (RCN), respectively.

The central aspect of NUPUS is the study programme which aims at fostering a coherent combination of education of young scientists and their research under the supervision of experienced principal investigators from applied mathematics, scientific computing, physics, environmental and civil engineering, geohydrology, petroleum engineering, and process engineering. Doctoral students have benefitted from several months of stays at foreign partner institutions and many scientific and soft skill courses and seminars.

Research in NUPUS has been structured into three categories: (a) fundamental methods and concepts, addressing, for example, the issues of hysteresis, interfacial areas, uncertainties, or upscaling of pore-scale processes; (b) numerical methods, dealing, for example, with the treatment of non-linearities in robust and efficient solution approaches; and (c) modeling strategies for selected applications, where a focus has been put on CO₂ storage in saline aquifers, biofilms in porous media, and thin technical porous media with hydrophobic structures as, for example, in fuel cells.

Scientific Outputs: The past years have led to a high international visibility of research and researchers affiliated or associated with NUPUS. More than 40 supervisors from the above-mentioned disciplines at the partner institutions in Germany, The Netherlands, and Norway have supervised countless young academics, PhD and M.Sc. students. NUPUS has further associated partner institutions in Germany, Norway, Poland, UK, Switzerland, USA, and Italy who actively participated in yearly workshops and seminars, two large international NUPUS conferences in Stuttgart (2009) and in Bergen/Norway (2013). They have co-authored a large number of NUPUS-related publications, including those in this special issue.

3 This Special Issue and the Future of NUPUS

For the time being, this NUPUS special issue of *Transport in Porous Media* marks the punch line of 9 years of successful research within the funding framework of the DFG (GRK 1398), NWO, and RCN. But this is not the end. NUPUS is in the process of being put into new structures. The Stuttgart Research Partnership **SRP NUPUS** is planned as a framework to continue porous media research with partner institutions worldwide, facilitating the exchange of students and scientists, promoting a shared use of infrastructures, data, and knowledge, and inciting the scientific exchange through publications and conferences. We congratulate and thank the Editors of this special issue of *Transport in Porous Media* (Bernd Flemisch, Jan M. Nordbotten, Wolfgang Nowak, and Amir Raouf) for this excellent compilation of recent work from the NUPUS scientific community.