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EDITORIAL

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This is a special issue of the Journal of Applied Mechanics, containing nine original papers on "Mixture Theory and Theory of Porous Media." Porous media play a prominent role in many application areas, for example, in biomechanics or soil mechanics. The continuum-mechanical description of the processes of and in porous media generally leads to coupled problems, which often have a multi-physical nature. In this context, poroelastic, thermal, chemical and biological fields have to be considered. Due to the highly complex microstructure of porous media, a direct discrete approach cannot be achieved in the majority of cases. Therefore, macroscopic homogenization methods have been established in the past decades, which allow for the thermodynamically consistent description of the strongly coupled phenomena via a smeared representation model. Notable methods among these are the mixture theory (MT) and the theory of porous media (TPM). This volume presents original papers using the MT or the TPM as the basis for various approaches to describe porous media for different tasks.

Several of the included articles deal with biomechanical issues. In the article by Bukac and Shadden, a poroelastic model for intraluminal thrombi (ILT) is presented, also capturing the flow within the ILT, its deformation and rupture. The model is coupled with blood flow and deformation of the arterial wall and can be used to study biomechanics in image-based models of abdominal aortic aneurysm (AAA). The work by Guang et al. addresses convectively as well as diffusively driven solute transport through the arterial wall based on a multiphasic mixture model. The authors demonstrated that solute transport depends on the structure of elastic fibers. They suggest that disruption of elastic fibers affects the transport of solutes of lower molecular weight. In the Miller et al. article, a continuum-mechanical model framework is developed for analyzing tumor growth and treatment in two- and three-phase systems. This can be used to derive macromodels of tumor behavior using the thermodynamically constrained averaging theory (TCAT), which provides a tight link to the microscale and constraints on allowable forms of closure conditions. In the publication by Shim & Ateshian, a hybrid biphasic model for biological tissue is developed with incompressible solid skeleton and compressible interstitial fluid. By evaluating the Clausius–Duhem inequality, thermodynamically consistent state functions for fluid pressure as a function of strain have been developed. This can be used to describe the fluid–structure interactions at interfaces between viscous fluids and porous-deformable biphasic regions, involving the exchange of fluids across these interfaces. The review article by Pierce discusses existing multiphase models and constitutive models for cartilage with large strains (i.e., finite deformation). This can be used to develop patient-specific 3-D clinical tools that (1) contribute to the understanding of structure–function relationships in cartilage, (2)

The original article has been corrected: Gerard A. Ateshian has been included as second author.

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improve the patient-specific assessment and treatment of cartilage damage, and (3) support advances in tissue engineering, i.e., the development of replacement materials for cartilage.

The paper by Eurich et al. investigates the effects of ice formation on frost-resistant plant tissue. For this purpose, a coupled thermohydromechanical model based on the TPM is developed. A numerical example reinforces the experimental finding that ice formation is mainly localized in the vallecular channels. The publication by Ramírez-Torres et al. deals with the relationship between nonlocal diffusion and the transport of chemical species in a composite medium. The asymptotic homogenization technique is used for model building. Based on asymptotic analyses, an analytical model reduction procedure for a poroelastic porous two-phase material in thin domains is developed in Armiti-Juber and Ricken. The homogenization is carried out in the framework of the TPM. Numerical examples impressively demonstrate the possible increase in computational efficiency by the reduced model while maintaining reliable solutions compared to the original full biphasic TPM model. For hydromechanical applications, the article by Ehlers develops the well-known classical equations of Darcy, Brinkman, Forchheimer and Richards in the framework of the TPM on the basis of precise continuum-mechanical and thermodynamically consistent investigations. Here, it was found that the classical equations are valid under certain constraints and that extended equations are valid for arbitrary cases in their domain. The work thus gives an excellent comparison between the well-known classical formulations for special applications and the general continuum-mechanical TPM and hence shows which assumptions and simplifications have been made in the classical formulations.

The present volume presents a broad cross section of recent developments in the field of continuum-mechanical description of porous media based on homogenization approaches in the framework of the mixture theory and the theory of porous media.

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