

**A MODELLING FRAMEWORK FOR NUMERICAL ANALYSIS OF  
GROUNDWATER AND MULTICOMPONENT TRANSPORT PROCESSES:  
TAFFETAS SOFTWARE SUITE.**

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**ABSTRACT**

This work introduces the concepts, and methodologies, used in a multiyear development project, with the aim to build a reliable software framework for numerical analysis of complex groundwater processes in multidimensional groundwater environments.

Performing simulations involving heat transfer and/or multicomponent solute transport, taking into account changes of fluid density and viscosity, in either porous or discretely fractured media is still a challenge for many applications. Beside the different resolutions and approaches to be embedded in the mathematical and numerical statement of the problem, the workload to adapt or upgrade numerical software for an ad-hoc situation is difficult, time consuming, and error prone. Additionally, realistic fully-three dimensional models require highly sophisticated techniques for the integrated conceptual design, mesh generation, and scientific visualization technology, to really understand their behaviour. Different discretization and iterative solvers, and preconditioning types are also prerequisite to handle highly non-linear and possibly non-symmetrical equations systems.

A flexible groundwater modelling framework is being developed, making extensive use of recent advances in automatic constrained meshing, geometric data structures, giving the possibility to build a more general and abstract geometric and data model independently on the numerical analysis. Model feature objects, such as fractures, boreholes, tunnelling, and underground excavations may be inserted and removed from the conceptual model, which stores different kinds of boundary conditions, initial conditions, and material properties on the conceptual model itself. Thus, enabling the analyst to compare different numerical approaches. TAFFETAS software suite is supporting an increasing number of finite element based approaches, including the standard conforming quadrilateral and hexahedral elements, and their mixed hybrid equivalents. Several Krylov based solvers are available for the linear sparse systems. Examples are provided for simulating density dependent phenomena, within different methods, and their performance is compared.

**keywords:** Software development, numerical modelling, density-dependent flow, finite elements.

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