8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

ADVANCES IN COMPUTATIONAL GEOSCIENCES

*Chongbin Zhao [1] and B. E. Hobbs [2]

[1] Computational Geosciences Research Centre, Central South University, Changsha, China
[2] CSIRO Division of Exploration and Mining, P. O. Box 1130, Bentley, WA 6102, Australia
Email: chongbin.zhao@iinet.net.au

Key Words: Applications, Geoscience problems, Computational geosciences.

ABSTRACT

In recent years, numerical methods and computer simulations provide a new way to deal with many geological, geophysical and geo-environmental problems, for which the traditionally-used theoretical and experimental methods may not be valid due to the large time and length scales of the problems themselves. This enables many hitherto unsolvable geoscience problems to be solved using numerical methods and computer simulations. In particular, through wide applications of computational mechanics to geoscience problems, a brand new branch, namely computational geosciences, has been established. However, due to the extremely large length and time scales, the numerical simulation of a real geological world also provides many challenging problems for the researchers involved in the field of computational mechanics.

The research methodology of computational geosciences is a comprehensive research methodology, which is formed by combining field observation, theoretical analysis, numerical simulation and field validation together. The primary aim of using this research methodology is to investigate the dynamic process and mechanism of an observed geological phenomenon, rather than to describe the observed geological phenomenon itself. The appropriate use of the research methodology of computational geosciences is usually comprised of the following four main steps: (1) the establishment of a conceptual model for a given geoscience problem; (2) the establishment of a mathematical model for the given problem; (3) the construction of a numerical simulation model for the given problem; and (4) the graphical display of the numerical results obtained from the numerical simulation.

In this presentation, we will summarize the recent advances in the field of computational geosciences. The main focus of this presentation is on the application of computational mechanics to ore body formation and mineralization problems within the upper crust of the Earth [1-12]. From a physical point of view, these problems can be described as fully coupled, multi-physics and multi-scale problems, namely fully-coupled problems between pore-fluid flow, heat transfer, mass transport and chemical reactions in porous media. Since convective pore-fluid flow plays an important role in ore body formation and mineralization, the numerical modelling of convective pore-fluid flow and related mineralization problems in hydrothermal systems within the upper crust of the Earth has been attracted extensive attention in recent years. In addition, other applications of computational mechanics to geoscience problems will also be discussed in this presentation. Although the research methodology of computational geosciences is mainly developed for dealing with ore body

formation and mineralization problems in the field of computational geosciences, it can be also used to solve a broad range of practical problems in other engineering fields.

REFERENCES

[1] Zhao, C., Mühlhaus, H.B., Hobbs, B.E., 1997. Finite element analysis of steady-state natural convection problems in fluid-saturated porous media heated from below. International Journal for Numerical and Analytical Methods in Geomechanics 21, 863-881.
[2] Zhao, C., Hobbs, B.E., Mühlhaus, H.B., 1998. Finite element modelling of temperature gradient driven rock alteration and mineralization in porous rock masses. Computer Methods in Applied Mechanics and Engineering 165, 175-186.
[3] Zhao, C., Hobbs, B. E., Baxter, K., Mühlhaus, H. B. and Ord, A., 1999. A numerical study of pore-fluid, thermal and mass flow in fluid-saturated porous rock basins, Engineering Computations 16, 202-214.
[4] Zhao, C., Hobbs, B.E., Mühlhaus, H.B., Ord, A., Lin, G., 2000. Numerical modelling of double diffusion driven reactive flow transport in deformable fluid-saturated porous media with particular consideration of temperature-dependent chemical reaction rates. Engineering Computations 17, 367-385.
[5] Zhao, C., Hobbs, B. E., Walshe, J. L., Mühlhaus, H. B. and Ord, A., 2001. Finite element modelling of fluid-rock interaction problems in pore-fluid saturated hydrothermal/sedimentary basins, Computer Methods in Applied Mechanics and Engineering 190, 2277-2293.
[6] Zhao, C., Lin, G., Hobbs, B.E., Wang, Y., Mühlhaus, H.B., Ord, A., 2002. Finite element modelling of reactive fluids mixing and mineralization in pore-fluid saturated hydrothermal/sedimentary basins. Engineering Computations 19, 364-387.
[7] Zhao, C., Lin, G., Hobbs, B.E., Ord, A., Wang, Y., Mühlhaus, H.B., 2003. Effects of hot intrusions on pore-fluid flow and heat transfer in fluid-saturated rocks. Computer Methods in Applied Mechanics and Engineering 192, 2007-2030.
[8] Zhao, C., Hobbs, B.E., Ord, A., Peng, S., Mühlhaus, H.B., Liu, L., 2004. Theoretical investigation of convective instability in inclined and fluid-saturated three-dimensional fault zones. Tectonophysics 387, 47-64.
[9] Zhao, C., Hobbs, B.E., Ord, A., Peng, S., Mühlhaus, H.B., Liu, L., 2005. Numerical modelling of chemical effects of magma solidification problems in porous rocks. International Journal for Numerical Methods in Engineering 64, 709-728.
[10] Zhao, C., Hobbs, B.E., Hornby, P., Ord, A. and Peng, S., 2006. Numerical modelling of fluids mixing, heat transfer and non-equilibrium redox chemical reactions in fluid-saturated porous rocks. International Journal for Numerical Methods in Engineering 66, 1061-1078.
[11] Zhao, C., Hobbs, B.E., Ord, A., Hornby, P., Peng, S., Liu, L., 2007. Mineral precipitation associated with vertical fault zones: the interaction of solute advection, diffusion and chemical kinetics. Geofluids 7, 3-18.
[12] Zhao C, Hobbs B E, Ord A., 2008. Investigating dynamic mechanisms of geological phenomena using methodology of computational geosciences: an example of equal-distant mineralization in a fault. Science in China, D-Series: Earth Science, In press.