

## Geofluids in the Netherlands: introduction

**J.M. Verweij**

Netherlands Institute of Applied Geoscience TNO - *National Geological Survey*,  
P.O. Box 80015, 3508 TA Utrecht, the Netherlands; e-mail: j.verweij@nitg.tno.nl

Manuscript received: March 2003; accepted: March 2003



### Introduction

Traditionally, geologists focussed their research on the solid part of the subsurface. Increasingly geoscientists are aware of the role of fluids in the structural, sedimentological, mineral and (bio)geochemical evolution of the Earth's crust.

Geofluids research focusses on fluid-related processes on geological timescales. It includes a wide variety of research on physical and chemical aspects of subsurface fluids (groundwater, petroleum, and geothermal, magmatic and metamorphic waters) in the Earth's crust, on microscopic to continental length scales. The significance of understanding fluid processes and, as a consequence, of geofluids research in exploration, use and sustainable management of natural resources (groundwater, oil, gas, geothermal energy, ore minerals and salt), storage of energy carriers and energy wastes, and prediction of natural geohazards and its consequences is increasingly recognised. The worldwide interest in – and understanding of – fluid flow in relation to various geological processes have advanced rapidly, especially since the early 1990's (Bethke 1985, 1989; Doligez, 1987; Garven, 1985; Hubbert, 1953; Tóth, 1980, 1987; and since 1990: Al-Aasm et al., 2002; Bredehoeft & Norton, 1990; Dahlberg, 1994; Garven, 1995; Ingebritsen & Sanford, 1998; Jamtveit & Yardley, 1997; Law et al., 1998; Lerche & Thomsen, 1994; McCaffrey et al., 1999; Mitchell & Grauls, 1998; Parnell, 1994, 1998; Pueyo et al., 2000; Van Balen, 1995; Verweij, 1993). The latest overview of geofluids research is

presented in the Proceedings of the Geofluids IV: Fourth international conference on fluid evolution, migration and interaction in sedimentary basins and orogenic belts (Verweij et al. 2003). These concepts, theories and methods pertaining to fluid flow in relation to various geological processes in different sedimentary basins have been very valuable for the research in onshore and offshore Netherlands.

### Objective of this special issue

This present issue of the Netherlands Journal of Geosciences/Geologie en Mijnbouw is intended to introduce research of geofluids in onshore and offshore Netherlands to a broad geoscientific audience by presenting an overview of different fields of the latest geofluids research carried out by academic and applied researchers.

### Geofluids in the Netherlands

Geofluids research of the subsurface of onshore and offshore Netherlands concerns the characterisation, evolution, migration and interaction of fluids in sedimentary basins. This issue includes papers on groundwater (Regnier & Jourabchi; Wildenborg et al.; Kooi & Groen; Bense et al.; and Bouw & Oude Essink) and on oil and gases (Verweij et al.; Schroot & Schüttenhelm). It presents studies on palaeo, present-day and future fluid flow conditions in relation to different geological processes.

Regnier & Jourabchi focus on the coupling between fluid flow, constituent transport and biogeochemical interactions. The aim of their paper is to provide a general mathematical approach to solving models of complex biogeochemical systems. They show that the mathematical models required to describe coupled transport and chemical reactions in many environments of the hydrosphere are fundamentally the same. Considering the interdisciplinary nature of such models, a Knowledge Base system for biogeochemical processes is proposed. Regnier & Jourabchi demonstrate the usefulness of the Knowledge Base approach through three examples of carbon dynamics in redox-stratified environments.

Wildenborg et al. investigated the suitability of Tertiary clays in the Netherlands for retrievable storage of radioactive waste by predicting future fluid flow conditions in these clays resulting from glacial loading. They describe the results of hydromechanical computer simulations and mechanical laboratory experiments that they used to analyse the effects of glacial loading by a thousand - metre - thick ice sheet on the permeability characteristics, fluid flow rates and the associated migration of radionuclides both within and out of Tertiary clays.

Kooi & Groen discuss the importance of taking geological conditions into account in the management of groundwater resources in coastal areas. They argue and show that awareness and knowledge of the influence of sedimentary loading and change of sea level on current hydrogeological conditions in such coastal zones can lead to improved characterisation of the distribution of hydraulic parameters and of the distribution of water quality. The relation between geological conditions and present-day hydrogeological conditions is continued with Bense et al.'s paper. They present an overview of the impact of faults on present-day hydrogeological conditions and on water-related phenomena at the ground surface in the Roer Valley Rift System, located in the southeastern part of the Netherlands and adjacent parts of Belgium and Germany.

Bouw & Oude Essink describe a palaeo fluid flow study. The study involved the reconstruction of the palaeo topography, the palaeo hydrostratigraphy and the possible development of topography-driven meteoric water flow during the Late Cretaceous inversion of the northern Broad Fourteens Basin in offshore Netherlands. Bouw & Oude Essink applied 2D numerical modelling of density-dependent topography-driven fluid flow for model scenarios with varying estimates of basin-scale permeability and water table head to evaluate the development of a freshwater lens and the possible subsolution of Zechstein salts. Another

example of a palaeo fluid flow study concerns the history of petroleum systems in the southern Broad Fourteens Basin discussed by Verweij et al. They applied 2D basin modelling in their integrated basin analysis study to evaluate the response of source rock maturation, and of petroleum expulsion, migration, accumulation and preservation to the geological evolution of the southern Broad Fourteens Basin. Verweij et al. also discuss the interaction between the hydrodynamic and hydrogeologic history of the basin and the history of petroleum systems and the effect of this interaction on present-day characteristics of petroleum accumulations in the basin. Finally Schroot & Schüttenhelm describe the assessment of the surface and subsurface expressions of shallow gas in offshore Netherlands by using 2D and 3D seismic surveys and higher frequency acoustic surveys. The authors state that knowledge of shallow gas is of importance because of its societal significance both as a resource and as a hazard (e.g. drilling hazard), and because it can improve the formulation of boundary conditions for safe and efficient storage of CO<sub>2</sub>. They identified numerous gas-related phenomena in offshore Netherlands. These phenomena include indications of gas accumulations efficiently sealed in shallow reservoirs as well as indications of leakage and migration of gas to the sea bed. Much of this leakage and migration was found to be situated over salt domes, with the accompanying normal fault above the domes acting as pathways for the fluids.

### Acknowledgements

I would like to thank especially the authors for their contribution to this special issue and I gratefully acknowledge the work of the reviewers.

### References

- Al-Aasm, I.S., Scotchman, I.C. & Verweij, J. (eds) 2002. Marine and Petroleum Geology 19 (no. 3). Thematic set on Origins, characterization and significance of fluids in sedimentary basins, 207-388.
- Bethke, C.M. 1985. A numerical model of compaction-driven groundwater flow and heat transfer and its application to the palaeohydrology of intracratonic sedimentary basins. *Journal of Geophysical Research* 90, B8, 6817-6828.
- Bethke, C.M. 1989. Modeling subsurface flow in sedimentary basins. *Geologische Rundschau* 78/1, 129-154.
- Bredhoeft, J.D. & Norton, D.L. (eds) 1990. The role of fluids in crustal processes. *Studies in Geophysics*. National Academy Press, Washington D.C., 165 p.
- Dahlberg, E.C. 1994. *Applied hydrodynamics in petroleum exploration*. 2<sup>nd</sup> edition. Springer-Verlag, New York, 295 p.
- Doligez, B. (ed.) 1987. *Migration of hydrocarbons in sedimentary basins*. 3<sup>rd</sup> IFP Exploration and Production Research Conference. Éditions Technip, Paris, 681 p.

- Garven, G. 1985. The role of regional fluid flow in the genesis of the Pine Point deposit. *Economic Geology* 80, 307-324.
- Garven, G. 1995. Continental-scale groundwater flow and geologic processes. *Annual Review of Earth Planetary Sciences* 23, 89-117.
- Hubbert, M.K. 1953. Entrapment of petroleum under hydrodynamic conditions. *The AAPG Bulletin* 37, 1954-2026.
- Ingebritsen, S.E. & Sandford, W.E. 1998. Groundwater in geologic processes. Cambridge University Press, 341 p.
- Jamtveit, B. & Yardley, B.W.D. (eds) 1997. Fluid flow and transport in rocks. Mechanisms and effects. Chapman and Hall, London, 319 p.
- Law, B.E., Ulmishek, G.F. & Slavin, V.I. (eds) 1998. Abnormal pressures in hydrocarbon environments. *AAPG Memoir* 70, 264 p.
- Lerche, I. & Thomsen, R.O. 1994. Hydrodynamics of oil and gas. Plenum Press, New York and London, 308 p.
- McCaffrey, K.J.W., Lonergan, L. & Wilinson, J.J. (eds) 1999. Fractures, fluid flow and mineralization. Geological Society, London, Special Publication 155, 328 p.
- Mitchell, A. & Grauls, D. (eds) 1998. Overpressures in petroleum exploration. *Bulletin du Centre de Recherches Elf Exploration Production Memoir* 22.
- Parnell, J. (ed.) 1994. Geofluids: Origin, migration and evolution of fluids in sedimentary basins. Geological Society, London, Special Publication 78, 372 p.
- Parnell, J. (ed.) 1998. Dating and duration of fluid flow and fluid-rock interaction. Geological Society, London, Special Publication 144, 284 p.
- Pueyo, J.J., Cardellach, E., Bitzer, K. & Taberner, C. (eds) 2000. Proceedings of Geofluids III: Third international Conference on fluid evolution, migration and interaction in sedimentary basins and orogenic belts, Barcelona, July 12-14. *Journal of Geochemical Exploration* 69-70, 714 p.
- Tóth, J. 1980. Cross-formational gravity-flow of groundwater: A mechanism of the transport and accumulation of petroleum (The generalized hydraulic theory of petroleum migration). In: Roberts III, W.H. and Cordell, R.J. (eds). Problems of petroleum migration. *The AAPG Studies in Geology* 10, 121-167.
- Tóth, J. 1987. Petroleum hydrogeology: a new basic in exploration. *World oil*, September 1987, 48-50.
- Van Balen, R.T. 1995. Tectonic control on the hydrodynamics and sedimentary record of extensional basins; inferences from numerical modelling and analyses of the Pannonian Basin. PhD thesis Vrije Universiteit Amsterdam, 201 p.
- Verweij, J.M. 1993. Hydrocarbon migration systems analysis. Developments in Petroleum Science 35, Elsevier, Amsterdam, the Netherlands, 276 p.
- Verweij, J.M., Doust, H., Peach, C.J., Spiers, C.J. & Swennen, R.A.J. (eds) 2003. Proceedings of Geofluids IV: Fourth international conference on fluid evolution, migration and interaction in sedimentary basins and orogenic belts, Utrecht, the Netherlands, 12-16 May 2003. *Journal of Geochemical Exploration* 79.