

**Seminar on:  
Geothermal Energy for sustainable development:  
the necessity of a multidisciplinary approach**

February 9<sup>th</sup>, 2010

Electrotechnical National Institute  
Corso Massimo D'Azeglio, 42 - Torino  
G. Vallauri Hall

- 10:00-10:15    **Welcome**  
*Marco Gilli, Deputy Rector Politecnico di Torino*  
*Mariachiara Zanetti, Head of DITAG – Politecnico di Torino*  
*Roberto Compagnoni, Emeritus Professor in Università di Torino*
- 10:15-10:30    **Introduction**  
*Francesca Verga, DITAG – Politecnico di Torino*
- 10:30-11:30    **Placing geothermal energy in the context of sustainable development**  
*Deborah J. Shields, Colorado State University*
- 11:30-12:30    **Advancing geothermal exploration by utilizing data, methods and knowledge from petroleum geoscience**  
*Hanneke Verwei, TNO Built Environment and Geosciences*
- 12:30-14:00    Lunch Break not included
- 14:00-15:00    **Geothermal Energy Production – Issues in Coupled Modelling and Data Assimilation**  
*Peter A. Fokker, TNO Built Environment and Geosciences*
- 15:00-16:00    **GPR Imaging of Flow in Discrete Fractures: Implications to Geothermal Resources Development**  
*George Tsoflias, The University of Kansas*
- 16:00-16:30    *Discussion and conclusion*

**Scientific Committee**

*Prof. Alberto Godio, Prof. Francesca Verga, Prof. Mariachiara Zanetti, Dr. Gian Andrea Blengini, Dr. Rajandrea Sethi*

**Aknowledgments**

The speakers have been granted by visiting professorships funded by Regione Piemonte. Thanks to the INRIM (National Institute for Metrological Research) and to the Earth Sciences Department of the Turin University for the kindly availability of the “G. Vallauri” Hall in the historical building of IEN (Electrotechnical National Institute).

## ABSTRACT

*Sustainable development is the stated long-term goal of the European Union, and its Sustainable Development Strategy provides a long-term vision of sustainability that views economic growth, social cohesion and environmental protection as equally important. In 2007 European leaders signed a binding agreement to source 20% of their energy needs from renewable by 2020.*

*In this context, geothermal energy offers a myriad of potential benefits providing a renewable and sustainable clean and safe energy source with little land use but its provision can also entail social, economic and environmental impacts that must be considered prior to investment and technical development.*

*The seminar will approach the exploitation of geothermal energy adopting a multidisciplinary approach. In the design of geothermal energy system technical but also socio-economic and bio-physical issues should be considered in order to identify and quantify the opportunity costs, trade-offs and long-term societal net benefits of geothermal developments, and how doing so leads to better decision making. The development of geothermal energy production poses important challenges for subsurface modelling. One of those challenges is the coupling of flow, geomechanics, and thermal behaviour. As an example, the coupling of geomechanics and flow covers the transport parameters of fractured rock which may change due to the geomechanical response of the fluid pressure, but also the occurrence of seismicity triggered by the injection of cold water under high pressure. In addition, the large uncertainties present in the reservoir characterization call for a stochastic modelling approach. This approach is required in the forecasting and decision support of geothermal operations, and as a consequence also in the inverse modelling or history matching. Much work is currently performed on the application of data assimilation techniques to reservoir engineering issues in the petroleum industry. Data assimilation is aimed at sequentially improving knowledge about the reservoir using measurements taken during the producing life of the field. The application of state-of-the-art data assimilation techniques for geothermal energy production, on coupled models and using measurements of very different types, is still a major challenge. Surface geophysical methods are used to explore for geothermal resources at the regional scale. Microseismic event monitoring provides estimates of fractured rock volume at the reservoir scale. Borehole logging gives formation properties at the well location. However, a need still exists for quantifying discrete fracture hydraulic properties and flow paths away from wells. Near-surface analogue studies at a fractured bedrock site show that ground-penetrating radar (GPR) has the capability to monitor flow and quantify transport of mass in discrete fractures. High-resolution remote observations of subsurface heterogeneous flow can have significant impact in the development of geothermal reservoirs.*

## INVITED SPEAKERS



**Dr. Peter A. Fokker** heads the reservoir geomechanics group in the team “Oil and Gas” of TNO Built Environment and Geosciences, and he is visiting professor at the Politecnico di Torino (DITAG) in reservoir engineering. His research interests lie in Petroleum Engineering, Reservoir Engineering, and Reservoir Geomechanics, with a key link to geology and remote sensing. His particular focus is on modelling: developing fast models for reservoir engineering and linking these to reservoir simulation for productivity prediction and well testing, and developing fast geomechanical models to predict subsidence, fault reactivation, and hydraulic fracturing. For the incorporation of data or measurements, he works on inverse models and data assimilation. Fokker holds an MSc and a PhD in physics from the University of Utrecht and is Technical Editor of the SPE Reservoir Engineering and Evaluation journal.



**Dr. Deborah Shields** is Affiliate Faculty in the Department of Economics at Colorado State University and a Visiting Professor in DITAG at the Politecnico di Torino in Italy. She holds an MSc in Mineral Economics from the Colorado School of Mines and a PhD in Ecosystem Science from Colorado State University. She worked for the U.S. Bureau of Mines, specializing in international mineral trade and mathematical modeling. In 1991, she became the Principal Mineral Economist for the U.S. Department of Agriculture Forest Service, Research and Development Division. In that position she directed the agency’s energy and mineral economics and mineral policy research programs, including a public-private effort to develop indicators of sustainability for the minerals sector. She was actively involved in the Mining Minerals and Sustainable Development project, acted as an advisor on minerals to the US delegation to WSSD, was a science advisor to the US delegation to Mining Ministries of the Americas, and has taught at and organized NATO-sponsored science workshops. She also managed a research program that provided ongoing information to USFS strategic planning on the American public’s values, objectives and beliefs about forests and rangelands. Subsequent to retirement from the USFS, Dr Shields has taught resource economics and sustainability theory, as well as run workshops on minerals in sustainable development in various countries, and continued her research and writing. Her current research interests focus on qualitative and quantitative sustainability assessments at multiple spatial scales, decision theoretic models, mineral scarcity, and value theory. Dr Shields is an active member of SME, past chair of the SME Sustainability Committee, and a member of the IMPC Sustainability Committee.



**Dr. George Tsoflias** received B.S. (1989) and M.S. (1991) degrees in geophysics from Virginia Polytechnic Institute and State University and a Ph.D. (1999) in geological sciences from the University of Texas at Austin. His professional experience as a geophysicist includes petroleum exploration for Mobil Oil from 1991 to 1995 and management of hydrocarbon resources for the U.S. Department of the Interior from 1999 to 2003. Since 2003 he has been a professor at the University of Kansas, Department of Geology. Tsoflias’ current research focuses on the development of ground-penetrating radar and seismic methods for near-surface hydrogeophysical investigations, the geophysical characterization of fractures, and geophysical exploration of the polar ice sheets.



**Dr. Hanneke Verweij** is a senior petroleum hydrogeologist at TNO, the Netherlands. She holds a Msc degree in hydrogeology and a PhD degree in earth sciences from the Vrije Universiteit Amsterdam. She has > 25 years of experience in applied and strategic research of fluid flow systems on different time and spatial scales. After performing groundwater resource studies in Colombia, and compiling a standard reference book on analysis and evaluation of well test data for groundwater studies, she started research on the application of hydrogeological knowledge for oil and gas exploration purposes in 1987. Since that time she has initiated and has been involved in national and international R&D projects concerning the analysis and interpretation of groundwater flow and pressure systems in developing sedimentary basins, and the significance of these systems for petroleum migration and accumulation. At present she is involved in several integrated basin modeling and mapping projects concerning elements and processes affecting petroleum systems, including thermal properties and processes. She has experience in university teaching on general and physical hydrogeology, including the role of fluids in geological processes (Utrecht University 1997-2001). She has published 3 books and more than 30 papers in international journals and conference proceedings, and is guest editor of 4 special issues of international journals.

## REGISTRATION FEES

Whoever wishes to attend the Workshop and the Conference is kindly requested to send the enclosed Registration Form to the Conference Secretariat to:

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The official language of the Seminar is English.

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