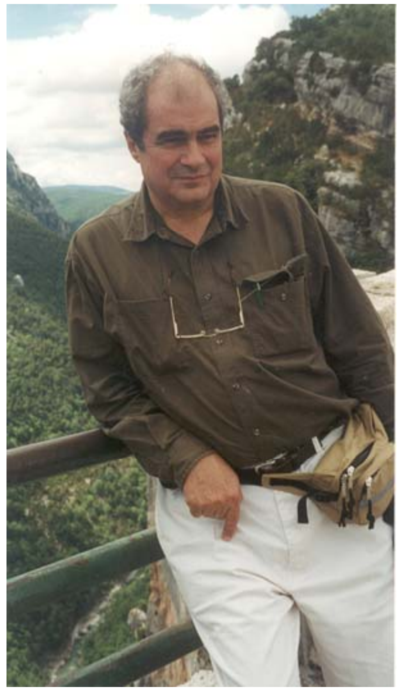

Paul Marinos

the 2010 Jahns Distinguished Lecturer

Dr Paul Marinos has been named the 2010 Jahns Distinguished Lecturer. The Association of Environmental & Engineering Geologists (AEG) and the Engineering Geology Division of the Geological Society of America (GSA) jointly established the Richard H. Jahns Distinguished Lectureship in 1988 to commemorate Jahns and to promote student awareness of engineering geology trough a series of lectures offered at various locations around the country. Richard H. Jahns (1915 – 1983) was an engineering geologist who had a diverse and distinguished career in academia, consulting and government.

Dr Paul Marinos received a Mining Engineering degree from the School of Mines of the National Technical University of Athens, Greece in 1966, a postgraduate degree in Applied Geology from the University of Grenoble, France, and his Doctorate in Engineering Geology from the same University in 1969. He worked for French and Greek design and construction companies until 1977 and then was elected as Professor at Democritus University in Northern Greece. Since 1988 Dr Marinos has been Professor of Engineering Geology in the School of Civil Engineering in the National Technical University of Athens and has served as head of the Geotechnical Section of the School for several years. From 2001 to 2004 and from 2006 to 2008 he was the Director of a Graduate Course in Tunneling and Underground Construction. He was a visiting Professor in the Geology Department of the University of Grenoble (1987) and of the School of Mines in Paris (2003).

Dr Marinos is a member of AEG and GSA and fellow of the Geological Society of London. He is a past President of the International Association of Engineering Geology and the Environment (IAEG), immediate past president of the Geological Society of Greece and honorary member of the International Association of Hydrogeologists (IAH).

Dr Paul Marinos has received several awards, including the Hans Cloos medal of IAEG, and the Andre Dumont medal of the Geological Society of Belgium. He was selected for the presentation of named lectures, including the 6th Glossop Lecture in London (2002), the 19th Rocha Lecture in Lisbon (2002), the 33rd Cross Canada Lectures Tour (2005), and the Rock Mechanics annual Lecture in Madrid (2006).

Dr Marinos and his team conduct research on a variety of applications of geology to engineering, mainly rock mass characterization, weak rock properties and behavior, with special emphasis to tunnel design. His work also covers landslides, dam geology, and engineering in karstic terrain. His other significant interest is the protection of historic monuments and archeological sites. Dr Marinos has authored or co-authored over 300 papers in journals or major conference proceedings. He was a key or invited lecturer in more than 40 conferences or special events. He has given lectures to University Courses or Workshops, among them the Federal Technical University (EPFL) in Lausanne, Switzerland, the Polytecnico of Turin, Italy, the University of Durham, U.K., the University of Coimbra, Portugal, the University of Kobe, Japan, the Black Sea University Romania, the Aristotle University of Thessalonica, Greece, and the Griffiths University, Australia. He has edited proceedings published by international publishers. Dr Marinos is a member of the Editorial Board of a number of prominent journals as “Engineering Geology”, “Bulletin of the International Association of Geology”,” Landslides”, “Environmental Geology”, “Rock Mechanics” and from 2009 “Environmental and Engineering Geosciences”.

Dr Paul Marinos has extensive industrial experience having served as consultant, independent reviewer and member of consulting boards or panel of experts on major civil engineering projects in Greece, France, India, Iran, Jordan, Morocco, Portugal, Saudi Arabia, South East Asia, Spain, Sweden, and Turkey.

The titles of Dr. Marinos’ lectures are:

1) Ongoing challenges in Engineering Geology for tunnelling in difficult ground
2) Geological constraints and geotechnical issues in mechanized tunneling
3) Tunneling through karstic rocks - How Engineering Geology needs Hydrogeologic input and logic
4) Rock mass characterization; a vehicle to translate Geology into the design of Engineering Structures
5) Geology in dam engineering. An evolving contribution of Engineering Geology for safety and efficiency
6) Geology of Athens, Greece. A case of urban geology for land use, construction of major engineering structures, hazard assessment and sustainable development

Requests for scheduling lectures should be directed to Paul Marinos at marinos@central.ntua.gr

Lectures will start in January 2010 and run through June 2010, the period that Paul Marinos will be on sabbatical leave in the United States. However some lectures can be accommodated a week before each of the annual meetings of AEG and GSA in the fall of 2010, since Paul Marinos will be back in the US to present his featured lecture at both of these meetings.

The University/College lectures can be arranged for a one hour presentation or a two hour presentation with a short break. Lecture content will be adjusted according to the field of study of students –geology, civil, mining– and whether they attend an applied geology program.

2010 Jahns Lecture abstracts

Ongoing challenges in Engineering Geology for tunnelling in difficult ground

The growth of infrastructure needs has increased demands for the excavation of tunnels in poor ground or varying geological conditions. This development includes site investigation techniques, analytical design method (notably numerical), risk analysis, techniques of construction, and monitoring.

The assessment of ground for design has to be based on a sound understanding of the regional geological rules and the establishment of a geological model where data and conditions are translated into an engineering geology description. Examples of geological models and cases from both mountain and urban tunnels under complex or difficult geological conditions are presented. These include the base tunnels in the Alps in a variety of conditions at great depth, tunnels through heavily folded formations with shear zones and cataclasites, Metro works in heterogeneous and weak ground and the selection of the appropriate TBM, and the project for the Gibraltar strait tunnel.

Tunnel design requires knowledge on the quality of the material in which the tunnel will be constructed. Engineering design requires numbers and the lecture explores and discusses methods that can be used by Engineering Geologists to assess the geological factors that have an impact on the design. Since the attempt of Terzaghi (1946) to describe the characteristics of rock masses, a number of rock mass classifications have been developed and play an important role in tunnel design, providing input data on strength and deformation properties of the ground for numerical models. Together with the rock mass properties, the in situ stresses field has to be estimated or measured and this is one of the most difficult tasks.

Although the role of engineering geology has been extended into the area of defining the design parameters, the idealization process, in the form of numerical analysis, should be driven by sound geologic reasoning together with the engineering logic.

The understanding of real behaviour is indeed absolutely necessary before any calculation is attempted. Thus, the engineering geological "I.D" of the geomaterial and the stress environment define this ground behaviour such us:

- Brittle failure of strong massive rock under high stress level.
- Gravitational falling or sliding of blocks or wedges defined by intersecting structural features or "chimney" type failure, or ravelling in disintegrated and heavily broken and loose masses.

- Formation of a "plastic" zone by shear failure under high stress relative to the strength of the rock mass with deformation problems or even squeezing.
- Swelling, in case of appropriate mineralogical constitution.

Comments on the methods for design for each of those cases are discussed and the presentation concludes with a discussion on excavation methods in conventional tunneling construction with special attention to support devices in order to deal with squeezing ground. Examples from a number of tunnels from around the world illustrate the design and construction procedures discussed.

Geological constraints and geotechnical issues in mechanized tunneling

Mechanized tunneling is evolving dramatically and every year constraints are reduced and TBM tunnelling is applied in new geological situations. Progressing from homogeneous, stable rocks through heterogeneous formation and unstable rocks, today the positive control of the face, or dealing with squeezing ground, constitute a great advance. Tomorrow we can expect the same TBM for any type of ground: the universal TBM**.**

In conventional tunneling, adjustments can be made even in the case of significant unforeseen changes of the geological conditions. On the contrary, mechanized tunnelling depends subversively on the geological conditions and the choice of the correct machine and operating mode is critical. Geological factors are discussed regarding both the type of geomaterial and its development in space, and the ground water conditions. The key issues for the choice of the appropriate TBM are the stability of the tunnel walls, the stability of the face and the control of surface settlements (for urban tunnels). The discussion on the selection covers all types of full face machines: open rock TBM, shielded TBM (single or double shield), TBM with pressurized face (notably slurry or earth pressure balance).

Particular geological conditions are given special attention, such as alternations and severe changes of the geological material with radically different quality along the alignment, fault zones, karstic conditions, squeezing ground, rock bursting of strong rock under high overburden. In the final choice possible adjustments and arrangements of the operational elements of the machine can be considered to deal with site specific geological conditions.

A number of case histories and the way problems from unforeseen geological conditions were faced will be presented. Among them:

- The Athens metro, Greece, with a shielded rock TBM which experienced severe problems of front breaks when crossing sheared rock,
- The Metro of Porto, Portugal, with an EPB boring unevenly weathered granite,
- The Hallandsas tunnel, Sweden with a mixed slurry shield TBM and an unexpected regime of low in situ stresses,
- The Evinos–Mornos mountain tunnel, Greece, with a double shield rock TBM and a successful crossing of squeezing flysh,
- The St Gotthard 57km long base tunnel, Switzerland, with rock TBMs crossing strong rocks with brittle behavior under very high overburden.

Tunneling through karstic rocks - How Engineering Geology needs Hydrogeologic input and logic

Although limestone and most carbonate rocks exhibit good geotechnical behavior, karstic conditions may induce hazards during tunneling operations and these may evolve into huge problems. Ground water and the crossing of voids and caverns, whether empty or filled, are the main problems. In order to estimate the probability of encountering such conditions and be prepared to face them, a thorough hydrogological study should complement the traditional site investigation program. This study has to embrace the whole hydrogeologic basin of the karstic aquifer, with background knowledge of the geologic history - the tectonic and paleogeographic evolution. In the lecture, hydrogeologic models are discussed depending on the internal karstic geometry of the aquifer and the position of the tunnel, either in the transfer or the inundation zone. Each model is associated with its own tunneling particularities in terms of hazards and countermeasures.

The measures for the confrontation of the problems are presented and discussed in terms of both groundwater inflow and dealing with voids, filled or empty. In many instances probing ahead of the tunnel face is imperative. The lecture is illustrated by a number of significant recent tunneling experiences from important tunnels around the world.

Rock mass characterization; a vehicle to translate Geology into the design of Engineering Structures

The integration of site geology with engineering requirements is the basis of Engineering Geology. Despite the record of case histories and the development of field and laboratory investigation techniques, there continues to be a need to describe site geology in terms appropriate for the analyses of deformation and stability of ground *in situ.* Two developments hold the potential to improve such description: the characterization of soil and rock, and the wider use of numerical modeling. Methods of characterization can now be tested with the aid of numerical analyses, and the suitability of the predictions they lead to can be tested with site instrumentation.

Since the attempt by Terzaghi in 1946 to describe the characteristics of rock masses, numerous rock mass classifications have been developed and the best known are those of Barton et al (1974) and Bieniawski (1976). These classification systems played an important role in tunnel design before the development of the numerical models. They continue to play an important role in providing initial estimates of the range of problems likely to be encountered and of solutions that can be considered and also in estimating rock mass properties for input into numerical models.
Hoek and Brown (1980) considered that more detailed rock mass property information would be required, as numerical modelling became more readily available and more widely used in design. They set out to develop a failure criterion and a classification system, the Geological Strength Index (GSI), specifically for the purpose of designing tunnels, slopes or foundations in rocks (Hoek and Marinos 2000). Here the geological character of rock material, together with a

visual assessment of the mass that forms, are used as a direct input for the selection of parameters relevant for the prediction of rock mass strength and deformability. Where anisotropy is not a dominant factor, this approach enables a rock mass to be considered as a mechanical continuum without losing the influence that its geology has on its mechanical properties. The Geological Strength Index has thus considerable potential for use in rock engineering because it permits the manifold aspects of rock to be quantified, enhancing geological logic and reducing engineering uncertainty.

A detailed description of GSI is presented with suggestions for its use and discussion on its limitations. One of the advantages of the index is that the geological reasoning it embodies allows adjustments of its ratings to cover a wide range of rock masses and conditions including complex rock masses with lithologic variety.

A number of examples from designs of engineering structures conclude the presentation.

Geology in dam engineering. An evolving contribution of Engineering Geology for safety and efficiency

“*To avoid the shortcomings associated with present practice requires first of all expert translation of the findings of the geologist into physical and mechanical terms. Next it requires the evaluation of the existing geologic conditions; and finally to assume for the design of the structure the most unfavourable possibilities.*

These mental operations represent by far the most important, most difficult, and most neglected tasks in the field of dam foundations” (Terzaghi, 1929)

This statement can be repeated today but the phrase “most neglected” is no longer true. Indeed developments are impressive with a sound understanding from all parties on the significance of knowledge of the geological conditions and the ground properties and behaviour.

Dams are among the civil engineering structures with the greater interaction with the ground and environment, increasing the responsibility of Engineering Geologists to translate geological findings into engineering design input. The lecture will consider all aspects of the involvement of engineering geology for both the site of the dam and the area of its reservoir.

For the site the information required refers to the quality of the foundation, the stability of the abutments, the watertightness of the foundation and ridges, the stability of the area of appurtenant structures, the specification of geological hazards and the reconnaissance for appropriate construction material.

The selection of the appropriate dam type is a vital decision. The function of each of the dam types and the significance of the geological conditions for such decisions is discussed.

Past dam failures, mostly due to neglect, ignorance or underestimation of geological features are always excellent in terms of lessons learned. A review is given of the causes of dam failures, from data of the International Commission of Large Dams, with discussion of some major failures around the world.

The geology of each dam site is unique. Even if it looks identical to another site, there will be differences in geological detail and, quoting again from Terzaghi, "*minor details constitute elements of major significance*". In this context the features and particularities of most common rocks are presented together with the variety of the elements of the structure a site may present, illustrated by case histories.

The assessment of permeability of the site and the criteria for the need of a grout and/or drainage curtain constitute an important chapter for the engineering geologist in site investigation, design and construction.

For the reservoir area the scale of consideration is totally different and regional hydrogeologic understanding is essential. A number of cases are presented with an emphasis on the existence of old river beds in different location and on karstic carbonate rocks. Instability of the mountain slopes around the reservoir may lead to disasters and important case histories are presented together with the countermeasures that can be undertaken.

Geology of Athens, Greece.

A case of urban geology for land use, construction of major engineering structures, hazard assessment and sustainable development

Unlike most capital cities, Athens does not have a history of continuous expansion; it is one characterized by the glory of the golden age of the 5th century BC, followed by decline and near annihilation and then resurgence in the 19th century when it became the capital of independent Greece. This was associated with increasing demands for expansion and the subsequent land use.

A brief review of the way that the ancient Athenians practiced geology in founding their city is presented. Particular attention is given to the building materials and the quarrying of marbles for monuments such as those on the Acropolis and the Parthenon which enjoys the reputation of being the most perfect Doric temple ever built (438BC). Water shortage due to climatic and hydrogeologic conditions imposed the 6th century BC Solonian rules for ground water management. To face groundwater scarcity Athenians constructed impressive aqueducts collecting water from the foothills of adjacent mountains with 20 km long tunnels, developed mainly during roman times (c 150AC), draining the surrounding poor aquifers.

The lecture follows the generic outline of the "Cities of the World" series of AEG. The geological model of the city is defined based on the geologic history and evolution. The alpine series of a flysch type slightly metamorphosed formation is the main bed rock of central Athens, named "the Athens schist". This is a highly heterogeneous folded and sheared formation providing weak rock masses. In the surroundings of the city post tectonic neogene, mainly marly, and quaternary deposits are developed. This development is modelled by a neotectonic structure with its activity to be demonstrated by the recent 1999 earthquake. The engineering geological and geotechnical data have been stored and processed through a relational database system, developed by the Geotechnical Division of the School of Civil Engineering of the National Technical University of Athens, providing information for the engineering behaviour of ground in all parts of the city.

The geologic constraints include the geologic aspects of natural risks that may be present in the metropolitan area: ground instability where applicable, earthquake induced geologic effects such as ground motion amplification or liquefiable soils and erosion processes with solid transport risk from the adjacent mountains. Erosion risk maps were prepared by processing lithologic, geomorphologic, hydrologic, and hydrogeologic data through GIS. These maps are most useful in the case of land management after wildfires. The ground zoning for seismic hazards was based on the ground categories provided by the Greek Seismic Code, taking into account basic engineering geological characteristics of soils such as lithology, thickness, density and consistency.

Resources such us building material, quarrying and environmental constraints are discussed. The hydrogeologic model is presented. The water supply of greater Athens is secured from a system of dams, some as far as 200km far from the city. A brief geological account is given on the weak foundations and the water tightness of these dams. Management of solid wastes and the choice of appropriate site for landfills is a priority issue at present.

A site specific assessment of ground conditions, using rock mass classification was applied successfully for the metro works of Athens. The method considers the rock mass competence for boring on the basis of criteria related to lithology, tectonic deformation (fracturing-folding-shearing), weathering and rock mass classification rating as well as the geometrical-structural position around the tunnel and ground water criteria. Experiences from this construction and how weak zones in the "Athens' schist" were crossed by the boring machines, either rock shielded or an earth pressure balanced TBMs, are highlighted.

In conclusion the various ways in which the citizens of Athens are made aware of the geological conditions of their city are discussed.