MODELAÇÃO DE SISTEMAS GEOLÓGICOS

Homenagem ao Professor Doutor Manuel Maria Godinho

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The International Association for Mathematical Geosciences

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Abstract
The International Association for Mathematical Geosciences (IAMG) is presented, starting with its origins and looking at the multiplicity of means IAMG has created to fulfill its mission.

The origins

The *International Association for Mathematical Geosciences* (IAMG) was founded on August 22nd, 1968, in Prague under the name of *International Association for Mathematical Geology*. According to its statutes, the aim of IAMG is to promote international cooperation in the application and use of mathematics in geological research and technology. This aim is often formulated as: *The mission of IAMG is to promote, worldwide, the advancement of mathematics, statistics and informatics in the Geosciences.*

IAMG was founded as a non-for-profit association at an impressive historical moment, as can be seen in Figure 1. The tanks were entering Prague, while the fathers of IAMG were approving the foundation of the association.

IAMG celebrated its 40th birthday in 2008, during the 33rd Int. Geological Congress, which took place in Oslo (Norway). At the general assembly held in Oslo in 2008, the name of the association was changed from *International Association for Mathematical Geology* to *International Association for Mathematical Geosciences*. The purpose of the change was to have a broader umbrella to cover all the areas which feel close to IAMG.

Figure 1. Foto taken from the Hotel Europe, Prague, 21/08/1968, by Bert Rowell. Reproduced in (Nemec, 1993).

IAMG is an associate member of the International Union of Geological Sciences (IUGS) and of the International Statistical Institute (ISI). This position, as a bridge between the two different fields of knowledge, is visualised in the IAMG-logo (Figure 2).

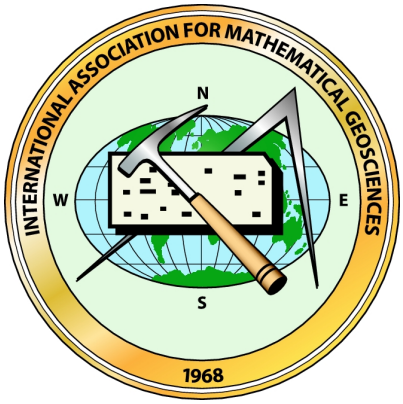

Figure 2. Logo of IAMG.

Nowadays, as shown in Figure 3, IAMG has 617 members in 56 countries.

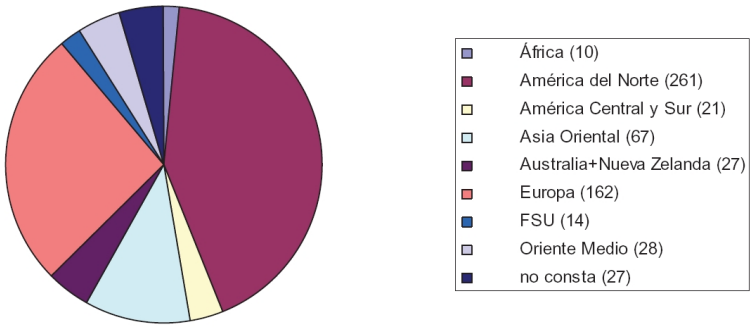

Figure 3. Distribution of IAMG members.

IAMG at present

Over the years IAMG has established several means to pursue its goals: publications, congresses, awards, special lectures, student chapters, student grants for research and travelling. Some details are given below. More recently, in the line of cooperating with other organizations which are professionally concerned with applications of mathematics and statistics to the biological sciences, earth sciences, engineering, environmental sciences, and planetary sciences, IAMG became a member of the International Year of Planet Earth.

Publications

IAMG publishes three scientific journals (Figure 4): *Mathematical Geosciences* and *Natural Resources Research*, published by Springer, and *Computers & Geosciences*, published by Elsevier. IAMG nominates the editors and the editorial board of each journal.

Figure 4. The three journals published by IAMG: *Mathematical Geosciences*, *Computers & Geosciences*, and *Natural Resources Research*.

Furthermore, IAMG publishes with Oxford University Press a series of monographs under the general title *Studies in Mathematical Geosciences* (SMG), and a biannual Newsletter (Figure 5.). IAMG also publishes its Conference Proceedings. In the past, the IAMG also published an online series named *Studies for Students*, but this series is no longer active.

Figure 5. IAMG newsletter.

Mathematical Geosciences

Mathematical Geosciences (Figure 4, left) is the flagship journal of IAMG. It was founded in 1968 as *Mathematical Geology*. The first issue was published in 1969. *Mathematical Geosciences* publishes quantitative methods

about geology, natural resources and the environment. It is an essential reference for those who develop and apply quantitative methods in the earth sciences and in problems of geoengineering. At present, the index of rejections is 52%; the impact factor for 2008 is 0.883; and the 5 years impact factor is 1.123. *Mathematical Geosciences* produces 8 issues a year.

The main subject represented in *Mathematical Geosciences* is *geostatistics* (see Table 1.), but there are other subjects well represented in the journal. The common factor that characterizes them is that they are devoted to mathematical methods applied to geoscientific issues.

Table 1. Principal subjects in Mathematical Geosciences (2000-2009). (Author: H. Burger, FU Berlin.)

Subject	Comments	Frequency
Geostatistics		140
Spatial statistics	Markov processes, etc.	67
Deterministic models	Fluid dynamics; geophysical models	46
Classical statistics	Multivariate; tests of hypothesis	45
Compositional data		31
Fractals		30
Stochastic models	Deterministic and random combined	23
Artificial intelligence	Neural networks; genetic algorithms	22
Time series		16
Mathematical morphology	Pattern recognition	14
3D Modelling		7
Directional data		6
Historical		5
Image analysis	Filtering, classification	4
Mathematical models		3

Computers & Geosciences

Computers & Geosciences (Figure 4, middle) was founded in 1975 as an attempt to give visibility to the advancement of computational facilities in the geosciences. It publishes all sorts of computational methods, from spatial analysis and geomathematics, to modelling, simulation, statistical methods and artificial intelligence, e-geosciences, geoinformatics, geomatics, geocomputation, image analysis, remote sensing, and GIS. The term *geosciences* is used in a broad sense, referring to the earth sciences: geology,

geophysics, geochemistry, oceanography, environmental sciences, atmospheric and planetary sciences, hydrology, physical geography, etc... At the present moment, the index of rejections is 65%; the impact factor for 2008 is 1.188; and the 5 year impact factor is 1.442. *Computers & Geosciences* publishes 12 issues a year.

A tabulation of subjects published in recent issues of *Computers & Geosciences* (see Table 2) showed that articles dealing with GIS are the most numerous in this journal, closely followed by studies in applied geophysics and data structures.

Natural Resources Research

Natural Resources Research (NRR) (Figure 4, right) is the youngest journal owned by IAMG. It was founded in 1992, and the first issue was published in the same year. At that time, the name of the journal was Non-Renewable Resources}. The start of the new journal has not been an easy one, and the ISI certification is still pending. NRR publishes quantitative studies about natural resources, including environmental, economic and risk aspects. Typical examples are the validation of sampling techniques; the comparison of exploration strategies; strategies for mining development, use and remediation; important factors for economical and/or technical success; and stochastic and deterministic models.

Table 2. Principal subjects in Computers & Geosciences (period analysed 2000-2009). (Author: H. Burger, FU Berlin.)

Subject	Frequency
Geographic Information Systems, GIS	218
Applied geophysics	190
Data structures	190
3D GIS/3D Modelling	140
Artificial intelligence	117
Geostatistics	112
Modelling, simulation	99
Remote sensing	88
E-geoscience, WWW	87
Environmental geology	80
Geoinformatics	67

Table 2 (continued)

Subject	Frequency
Geochemistry, general	65
Engineering geology	62
Hydrogeology	45
Compositional data	39
Statistics	33
Mathematical geology	24
Nonlinear dynamics, incl. fractals, multifractals	16
Time series analysis	10

Studies in Mathematical Geosciences

The series *Studies in Mathematical Geosciences* is published by Oxford University Press. In the words of its founding editor, Richard B. McCammon, *this series ... provides contributions from the geomathematical community on topics of special interest in the Earth sciences. As far as possible, each volume in the series will be self-contained and will deal with a specific technique of analysis. For the most part, the results of research will be emphasized. An important part of these studies will be an evaluation of the adequacy and the appropriateness of present geomathematical and geostatistical applications. It is hoped the volumes in this series will become valuable working and research tools in all facets of geology. Each volume will be issued under the auspices of the International Association for Mathematical Geology.*

Presently, the series includes eight titles, some of which are already sold out.

1. Use and Abuse of Statistical Methods in the Earth Sciences, Size (Ed.) 1987.
2. Oil and Gas Forecasting: Reflections of a Petroleum Geologist, L. Drew, 1990.
3. Geostatistical Glossary and Multilingual Dictionary, R.A. Olea (Ed.) 1991.
4. Techniques for Determining Probabilities of Geologic Events and Processes: A Review, Hunter & Mann (Eds.) 1992.
5. Computers in Geology: 25 Years of Progress, J. Davis & U. Herzfeld (Eds.) 1993.

6. Modern Spatiotemporal Geostatistics, Christakos, 2000 - 3rd printing.
7. Geostatistical Analysis of Compositional Data, V. Pawlowsky-Glahn & R. Olea, 2004.
8. Statistical Methods for Estimating Petroleum Resources, Lee, 2007.

Meetings

Through its Meetings Committee, IAMG supports the organization of its own yearly conference, except for years when the International Geological Congress (IGC) takes place, in which the IAMG holds a set of sessions at the IGC instead. The last meetings have been

- IAMG 2009 - Stanford University; Stanford, CA, USA; August 23 - August 28, 2008; http://iamg09.stanford.edu;
- IAMG 2010 - Eötvös Loránd University; Budapest, Hungary; August 29 - September 2, 2010; http://www.iamg2010-budapest.hu; while the next meeting will be
- IAMG 2011 - Salzburg, Austria; September 5--9, 2011;\\ http://iamg2011.at.

All these meetings are well attended by scientists working in Mathematical Geosciences, and are thus an excellent place to make new acquaintances in this field of research.

IAMG organizes special sessions at the meetings of the IGC, and also invited paper meetings at the congresses of the ISI (International Statistical Institute). The next meetings to take place are

- ISI: 2011 - 21-26 August, Dublin, Ireland;
- IGC: 2012 - 2-10 August, Brisbane, Australia.

But the IAMG also supports other related meetings and courses, such as:

- CoDaCourse (Course on compositional data analysis), Barcelona, Spain, 5-9 July 2010.
- Quantitative image analysis of minerals and rocks, 28-29 August 2010, Eötvös Loránd University, Budapest, Hungary.
- International School of Fluid Geochemistry, 21-24 September 2010, Abbadia San Salvatore, Siena, Italy.
- CoDaWork (Compositional Data Workshop), Girona, Spain, 10-13 May 2011.

Awards

The IAMG has 4 major awards. An international committee selects the winners among the candidates nominated by members of IAMG. Any member of the association can present candidates. On even-numbered years the following awards are given:

- **William Christian Krumbein Medal** - This is the highest award given by the Association. It is awarded to senior scientists for career achievement, which includes distinction in application of mathematics or informatics in the earth sciences, service to the IAMG, and support to professions involved in the earth sciences. There is no stipulated preference for fields of application within the earth sciences.
- **John Cedric Griffiths Teaching Award** - This award is presented to honor outstanding teaching, especially for teaching that involves application of mathematics or informatics to the Earth's nonrenewable natural resources or to sedimentary geology.

On odd-numbered years the following are given:

- **Felix Chayes Prize for Excellence in Research in Mathematical Petrology** - It is a cash prize endowed in honor of Felix Chayes that is given to recipients of exceptional potential and proven research ability. The prize is given for outstanding contributions to statistical petrology or related applications of mathematics or informatics.
- **Andrei Borisovitch Vistelius Research Award** - Given to a young scientist for promising contributions in research in the application of mathematics or informatics in any field of the earth sciences. A recipient should be 35 years or younger at the end of the calendar year for which he or she has been selected for the award.

Furthermore, the IAMG has established the figures of **Distinguished Lecturer**, who prepares a series of lectures—preferably on a variety of subjects in the mathematical geosciences—to be presented in places where IAMG conferences are not normally held, and of **Georges Matheron Lecturer**, who should be a scientist with proven research ability in the field of spatial statistics or mathematical morphology. This lecture is presented at the annual conference of the IAMG.

The list of awardees, Matheron Lecturers and **Distinguished Lecturers** of IAMG can be found on www.iamg.org. The last ones have been

- 2009-2010 Roussos Dimitrakopoulos, professor, holds the Canada Research Chair (Tier I) in “Sustainable Mineral Resource Development

and Optimization Under Uncertainty – BHP Billiton", at the Department of Mining and Materials Engineering, McGill University in Montreal, Canada;

- 2008 Donald Myers, Emeritus Professor of Mathematics and Hydrology at the University of Arizona, USA;
- 2007 Vera Pawlowsky-Glahn, professor at the Department of Computer Science and Applied Mathematics of the University of Girona, Spain;
- 2006 Larry W. Lake, professor of the Department of Petroleum and Geosystems Engineering at The University of Texas at Austin (USA) and director of the Enhanced Oil Recovery Research program;
- 2005 Larry Drew, of the U.S. Geological Survey, USA;
- 2004 Frederick P. Agterberg, of the Geological Survey of Canada;
- 2002 John C. Davis, of the Kansas Geological Survey (USA) and author of the classic text "Statistics and Data Analysis in Geology";

while the Distinguished Lecturer for 2011 is a renowned Portuguese scientist,

- Prof. Dr. Amilcar Soares, from the Centro de Modelização de Reservatórios Petrolíferos.

Other awards and honours established by IAMG are

- The *Best paper award* – Each IAMG journal may select every year the most outstanding paper. Selection of Best Paper is made by a commission appointed by the journal's Editor-in-Chief from members of the journal's editorial board and the Association at large. Each selection commission consists of at least five members.
- The *Best reviewer award*, recently established by *Mathematical Geosciences* to acknowledge the contributions of reviewers.
- *Honorary member*, to recognize people for their contributions to mathematical geosciences and/or to IAMG.
- The *Certificate of Appreciation*, which recognizes exceptional work on behalf of IAMG that is beyond normal expectations, or outstanding donation to the IAMG of time, skill, or financial resources. It may recognize specific effort by individuals upon completion of major tasks. Examples: Editors, Chairs (and possibly members) of committees or commissions that require unusual amounts of time, organizers of annual IAMG conferences.

Student Chapters

Student Chapters were established first in 2004. Up to date, the IAMG has acknowledged 9 **Student Chapters**:

1. 2004: Southern Illinois University – Carbondale, Illinois, USA.
2. 2004: China University of Geosciences – Wuhan, China.
3. 2005: Freiberg University of Mining & Technology, Germany.
4. 2006: University of Alberta – Edmonton, Alberta, Canada.
5. 2006: Stanford University – Stanford, California, USA.
6. 2008: Sun Yat-Sen University – Guangzhou City, China.
7. 2009: University of Colorado at Boulder, Colorado, USA.
8. 2009: ENSG – Nancy University, Nancy, France.
9. 2010: ITC – University of Twente, The Netherlands.

The 10th application is now under consideration.

An IAMG Student Chapter is an active organization of IAMG student members with the purpose of increasing the IAMG's visibility and promoting mathematical geology, geomathematics, and geoinformatics. IAMG Student Chapters are not autonomous institutions, but part of the IAMG. All members and officers of an IAMG Student Chapter must be IAMG members. A Student Chapter may receive funds from the IAMG and exercise its own discretion in using them as long as the uses are compatible with the goals of the IAMG and are approved by the IAMG.

Mathematical Geosciences in Portugal

The disciplines of geostatistics and geomathematics, came to Portugal thanks to the visionary mind of Prof. José Quintino Rogado (Instituto Superior Técnico). In the late 1960's he sent some of his students to take courses in Fontainebleau with Georges Matheron (Geostatistics) and Jean Serra (Mathematical Morphology), basically aiming to tackle the problems of the mining industry (mostly in Angola, former colony), with the flourishing new approaches.

Another important Portuguese pioneer in this field was Prof. Manuel Maria Godinho. Some of his most important publications of the 70´s and 80´s in this field are listed at the end of this paper. They show his early and broad interest for Mathematical Geosciences. He started in 1973/1974 a course in Geomathematics, for the degree of Geology of the University of Coimbra, that still exists! In the 70´s and early 80´s he did some work for the National Uranium Company (ENU) using mathematical methods to optimize the design of open pits and geostatistical methods for ore reserve es-

timation. In most of his research work he used geomathematical methods as a tool to understand mineralogical and petrological problems. From 1990 to 2010 he published many more papers using geostatistics, factor analysis, trend surface analysis (polynomial and Fourier series), analysis of characteristics, fractals, correspondence analysis and other geomathematical methods. The most elaborated are probably some papers using mathematical methods to simulate the cooling of granitic plutons and heat transfer to the country rock. In the last few years Prof. Godinho has dedicated most of his attention to the carbon cycle, including also some mathematical modeling.

The Third International Geostatistics Congress, organized in Troia (Portugal, 1992), and the first conference of the geoENV series—Geostatistics for Environmental Applications— which took place in 1996, were two remarkable milestones that definitively contributed to the consolidation and the spread of those disciplines in different portuguese schools and groups linked to the environment, the soil sciences, remote sensing and petroleum.

Invitation

Let us finalize this short report with a warmhearted invitation to join our group (Fig. 6). Together, we can promote and advance the various fields of *Mathematical Geosciences*, alone we are nothing!

Acknowledgements

Thanks are due to Prof. Neves and Prof. Soares for providing information on Mathematical Geosciences in Portugal.

Figure 6. IAMG 2009 annual meeting at Stanford.

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