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Rogério Rocha
João Pais
José Carlos Kullberg
Stanley Finney *Editors*

STRATI 2013

First International Congress on Stratigraphy
At the Cutting Edge of Stratigraphy

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Editors

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First International Congress on Stratigraphy

At the Cutting Edge of Stratigraphy


Earth Sciences Department
Centre in Geological Science and Engineering
International Commission on Stratigraphy (IUGS)

Springer

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Foreword

This 1st International Congress on Stratigraphy provides an excellent opportunity for presenting an inventory of our discipline more than 200 years after its birth and one century after the publication of the first treatise on stratigraphy (Grabau 1913) which established this subject as an entity in its own right in the area of geosciences. The state of the art presented by the authors of the plenary conferences and by the coordinators of the different topics makes it possible to highlight the main trends and prospects.

To begin with, it should be remembered that stratigraphy is not an abstract science or simply the fruit of computer modelling. It is an observation science that must, as a priority, be based on field data followed by analysis in the laboratory, and on regional studies that may combine a very great variety of analytical methods. These are the essential references—after having eliminated the local contingencies—for more global interpretations.

Four major features can be recognized in the development of our science over the last few decades, driven in particular by oil exploration and the study of the oceans: diversification of methods, putting into question, multidisciplinarity and extension of the fields of application.

Diversification of methods. Besides biostratigraphy which historically was the first approach used for dating and correlations, many other approaches are now used such as: genetic stratigraphies, chemostratigraphy, magnetostratigraphy (mainly geomagnetic field reversals), cyclostratigraphy, clays mineralogy, isotope geochronology, tephrochronology and so on.

Putting into question by objective and critical analysis of the different techniques and thanks to the intersecting perspectives of researchers using different tools. Biostratigraphy has thus grown stronger through a multiplication of index fossils (particularly in micropaleontology) and has been enriched by fruitful exchanges with other approaches (palaeoecology, taphonomy, sedimentology, palaeogeography, molecular biology, isotope geochronology, magnetostratigraphy) which have made it possible to understand better the signification of the appearance and disappearance of taxa, evaluate any diachronism of FAD and LAD and, inversely, to contribute effectively to the reconstitution of palaeoenvironments on various scales and to constraint timetrees. In chemostratigraphy, it has been possible to evidence the contradictory signification of various signals or the

different durations of negative and positive carbon isotope spikes. Although cyclostratigraphy may provide incomparable metronomes, it would seem that the durations of the various orbital parameters are not constant because of the chaotic behavior of the solar system. Only, the 405Kyr eccentricity is stable at least over the last 250 Ma and can be used for astronomical calibration of Mesozoic and Palaeozoic.

Multidisciplinarity Its growing importance, in a spirit of integrated stratigraphy, has three favorable consequences:

- greater dating and correlation accuracy, by means of an iterative process of exchanges between the results of various stratigraphic methods, for instance, by coupling the results of isotopic chronotratigraphy with cyclostratigraphic sequences;
- perfecting of the Geological Time Scale which provides the temporal framework for the geosciences. The GSSPs put in place gradually since 1977 must provide stratotype boundaries materializing the base of each stage by using the most varied tools to propose real-time lines identifiable on the scale of the globe. *A contrario*, experience shows that an insufficient diversity of the specific markers is currently calling into question certain limits that must be reviewed. Furthermore, various GSSPs must still be determined and validated, in particular for the Carboniferous, Permian and Cretaceous. As for the Quaternary, must the Anthropocene—attempt to recognize formally the substantial acceleration in human deduced changes to our planet during historical times—be treated as a formal chronostratigraphic unit with a golden spike?
- the research of causes for planetary changes. The major tendency of stratigraphy is now to try building unitary models in the organization of geological objects which are likely to show and explain the existence of logical relations between stratigraphic signals. But it must be borne in mind that nothing is ever definitively acquired: "a geologist, like any detective, must always work with multiple hypotheses and as many tools as possible to help narrow the possibilities and to discover the fascinating history of our world."

Extension of the fields of application. The utilization of stratigraphic approaches is not limited simply to sedimentary entities and our planet. Volcanic formations are also concerned, whether for elaborating a Time Scale of Volcanic Processes or for mapping volcanic regions involving the use of information provided by lithostratigraphy, chemostratigraphy, isotope geochronology and even sequence stratigraphy. And now, various stratigraphic methods are also being used to study planets (Moon, Mars, Venus, etc.) in order to establish a Planetary Time Scale comparable to the Geological Time Scale for Earth.

The great success of this Congress—which can be seen not only in the number of contributors and the quality of their works, but also in the great diversity of nationalities present—bears witness to the vitality of our science and to the need to organize such forums periodically, making it possible to confront concepts, methods, and results. So, you should count on a sequel to this.

Jacques Rey
Honorary President of STRATI 2013

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Scientific Program

Theme A. Principles and Methods of Stratigraphy

Plenary session: Stanley Finney (USA)

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Events Stratigraphy	Roberto Iannuzzi (Br)	Shen Shuzhong (Cn)	
Paleogene events, Evolution and Stratigraphy	Simonetta Monechi (I)	Noel Vandenberghe (B)	Laia Alegret (E)
Cyclostratigraphy and recent developments in the astronomical calibration of the Geological Time Scale	Silvia Gardin (I)	Bruno Galbrun (F)	Slah Boulila (Tun)
GSSP and Stratotypes	Stephen Hesselbo (UK)	Markus Aretz (D/F)	
Advances in isotopic Geochronology	Igor Villa(CH)		
Teaching of Stratigraphy, geological heritage and Geoethics	Jesús Martinez-Frias (E)	Patrick de Wever (F)	
Planetary Stratigraphy (Mars)	Kenneth Tanaka (USA)	Cathy Quantin-Nataf (F)	
Phylogeny, Palaeobiodiversity, and Palaeogeography	Joseph Palfy (H)	Michel Laurin (F)	
Paleozoic Stratigraphy and Palaeogeography	Elise Nardin (F)	Thijs Vandenbroucke(B)	

Theme B. Regional Stratigraphy

Plenary session: Bruno Vrielynck (F)

Themes	Coordinators	
Regional Stratigraphy s. l.	Andrzej Wierzbowski (Pl)	Francis Hirsch (J)
Stratigraphy of Iberian and Mediterranean Basins	Cristino Dabrio (E)	Moussa Masrour (Mar)
Rodinia and Gondwana Stratigraphy and geochronology	Ulf Linnemann (D)	Alan Vaughan (UK)
Assemblage and breakup of Pangea	Brendan Murphy (Can)	Gabriel Gutierrez-Alonso (E)

Theme C. Applied Stratigraphy

Plenary session: Vitor Abreu (Br)

Themes	Coordinators		
Sequence Stratigraphy, Seismic Stratigraphy, and Seismic Geomorphology	Michael Holz (Br)	Andy Davies (UK)	
Chemostratigraphy, Magnetostratigraphy, Chronology, Palaeoenvironments, and correlations	Jean François Deconinck (F)	James Ogg (USA)	
Stratigraphy applied to oil industry	Kenneth T. Ratcliffe (UK)	Pierre Muzzi Magalhães (Br)	
The Quaternary System and its Formal Subdivision	Martin Head (Can)	Philip Gibbard (UK)	Thijs van Kolfschoten (NL)
Fossil vertebrates in Stratigraphy	Louis Jacobs (USA)	Eric Buffetaut (F)	
Fossil invertebrates in Stratigraphy	Sixto Fernández-López (E)	Jingeng Sha (Cn)	
Microfossils in Stratigraphy	Bruno Granier (F)	Emanuela Mattioli (F)	
Terrestrial Mesozoic Stratigraphy	Miguel T. Antunes (P)	Zhonghe Zhou (Cn)	
Volcanic Stratigraphy	Gianluca Groppelli (I)	Joan Marti (E)	
Stratigraphy in Palaeoceanography	Fátima Abrantes (P)	José Abel Flores (E)	

Editorial

Since the beginning of this century, the International Geological Congress has examined the decisive role played by Earth Sciences in achieving a greater quality of life for humanity. Topics such as the study of current and past climate change, the development of sustainable energy technology, environmental impact assessment, and geological site selection for industrial infrastructures are crucial to the future planning of a truly sustainable form of development. At the base of all these domains, Geosciences and geologists, broadly speaking, have come, and must continue, to play an increasingly leading role. Except in a few selected cases, this need was previously ignored by policy-makers in many of our countries, given their general lack of interest in the Geosciences. However, we are now witnessing a new attitude, perhaps influenced by the global needs of the mining and oil industries.

Let it be said here that no discipline within the Geosciences is as comprehensive of scientific knowledge as that of stratigraphy. Stratigraphy is a geoscience speciality that involves numerous researchers and practitioners worldwide and has many applications, with growing importance in scientific, technological, economic, and environmental fields.

The International Congress on Stratigraphy—STRATI 2013 followed the decision to internationalize the STRATI conferences previously organized by the French Committee of Stratigraphy, the last one of which was held in Paris in 2010. The Congress is being held under the auspices of the International Commission on Stratigraphy (IUGS), and it has been organized within the Department of Earth Sciences and the Research Centre in Geological Science and Engineering from the Faculty of Sciences and Technology of the Universidade Nova de Lisboa (New University of Lisbon) (Portugal).

The overall theme, "At the Cutting Edge of Stratigraphy," reflects the recent advances in research in the field of Stratigraphy, new methodologies, applications for industry, and needs for society in general. The Congress included a vast program comprising 24 sessions covering three main themes: A—Principles and methods, B—Regional Stratigraphy, and C—Applied Stratigraphy.

The progress of scientific knowledge in this area is remarkable and the increasingly important interaction of stratigraphy with other areas of the Geosciences. The volume published under STRATI 2013, with texts about

the "state-of-the-art" on the various topics discussed in the Congress, and authored by members of the Scientific Committee, shows that the diversity of methods used in studies of this nature and the stratigraphic advancement of such knowledge in recent years already go beyond our planet.

The Organizing Committee was honored by the presence of such a vast and competent scientific community and thanks all for your participation. Particular thanks are due to colleagues, students, supporters, and sponsorships who participated in the organization of the Congress and whose support was essential for the high scientific quality of the communications that were presented, and which are now published.

Lisbon, October 2013

Rogério Rocha
João Pais
José Carlos Kullberg
Stanley Finney

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