CHALLENGES TO CHEMICAL GEOLOGY

Refereed Papers from MAEGS-10

Edited by
Martin Novák and Jeff Rosenbaum

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Preface

This Special Conference Volume offers original contributions from the 10th Meeting of the Association of European Geological Societies (AEGS), held in the West Bohemian spa of Karlovy Vary (Carlsbad), Czech Republic, in September 1997. It contains 11 refereed papers covering various aspects of modern geochemistry, including both high temperature and environmental topics. When organizing a scientific meeting, the key to success has been proven to lie in delegating responsibilities. This is why I invited my three young collaborators to write the introductory paragraphs for the reader of this volume: The present Secretary of AEGS J. Wiegand recapitulated the history of the Association, and you will find his account on the following page; T. Nield, a journalist by training, penned a short MAEGS-10 retrospect, while J. Rosenbaum, my guest co-editor, tried to answer his own question: "What really are the greatest challenges to chemical geology as the discipline enters its second century?"

This Special Volume owes its existence to those who worked tirelessly to make MAEGS-10 a smoothly run conference. I would like to acknowledge the enthusiasm of MAEGS-10 organizers, František Veselovský, Václav Kachlík, Eva Pačesová, Jaroslava Zusková, Vojtěch Janoušek, Eva Riedlová, Zdeněk Táborský, Ferry Fediuk and many others. Beyond MAEGS-10, I am especially grateful for the time and effort committed by those who reviewed submitted manuscripts carefully and critically. I thank my home institution, the Czech Geological Survey, for its generous support to our activities related to MAEGS-10 and to the preparation of this volume. Special thanks go to Dr. Zdeněk Kukal, the Survey's Past Director, for being the first person to suggest publishing a collection of papers from MAEGS-10 by the Publishing House of the Czech Geological Survey. Finally, on behalf of the Executive Committee of AEGS, I would like to express our gratitude to the outgoing Secretary of the Association, Dr. Benoit Deffontaines, for his dedication and diplomatic skills shown over the long past seven years.

Dr. Martin Novák
President of the Association of European Geological Societies
MAEGS-10 Chairman

The History of AEGS – Association of European Geological Societies

JENS WIEGAND

The origins of AEGS are embodied in a printed letter in English and French by Sir Kingsley Dunham of June 1974 which was widely circulated throughout Europe. This accompanied the First Circular announcing the 1st Meeting of European Geological Societies (MEGS), under Sir Kingsley Dunham's Presidency, with the theme "Europe – from Crust to Core" which was held in Reading, United Kingdom in September 1975.

A Bridging Committee for the future organization of MEGS was established in 1975 under Dr. J. V. Hepworth's Chairmanship. MEGS-2 was held at the Free University of Amsterdam in May 1978 with the theme "Europe – Basins and Source Areas". The Bridging Committee endeavoured to establish a European Geological Association to achieve continuity of MEGS and draft statutes by the end of MEGS-2. The statutes were adopted in Amsterdam on May 11th, 1978. It was hoped to formalize the constitution of the European Geological Association (EGA) during the Paris meeting of the International Geological Congress in the summer of 1980.

The two following meetings were held in Erlangen, Germany in early June 1982 under the theme "Europe on the Geological map" (MEGS-3), and in Edinburgh, Scotland in April 1985 under the theme "The Evolution of the European Litosphere" (MEGS-4). The latter meeting coincided with the 150th Anniversary of the Edinburgh Geological Society.

The "Association of European Geological Societies" (AEGS) was formed on October 9, 1987 in Dubrovnik, Yugoslavia during MAEGS-5 held under the theme "Orogeny, Magmatism and Metallogeny in Europe". Since 1988 AEGS has the status of an Affiliated Organisation of the International Union of Geological Sciences (IUGS).

Thereafter, meetings were held in the following order:

MAEGS-6: Lisbon, Portugal – October 1990, "The Atlantic and its Relation to Europe"
MAEGS-7: Paris, France – September 1991, "Seismic and Drillhole Investigation of the European Crust"
MAEGS-8: Budapest, Hungary – September 1993, "Evolution of Intramontane Basins on the Example of the Pannonian Basin with Particular Emphasis on the Sequence Stratigraphy and Neotectonics"
MAEGS-9: St. Petersburg, Russian Federation – September 1995, "Precambrian of Europe: Stratigraphy, Structure, Evolution and Mineralization"
MAEGS-10: Carlsbad, Czech Republic – September 1997, "Challenges to Chemical Geology".

Dr. Jens Wiegand is at the Geology Department of University of Essen, Germany. He serves as the Secretary of AEGS.

The Making of MAEGS

TED NIELD

The 10th biennial meeting of the Association of European Geological Societies (MAEGS-10) was held in Karlovy Vary (Carlsbad), in the Czech Republic from 1–5 September 1997. It attracted 100 delegates from 17 nations and four continents to discuss the broad theme of Challenges to Chemical Geology.

The Association of European Geological Societies is the only grouping of national societies, and its function – apart the high-minded one of fostering understanding between the geologists of wider Europe – is to organize these biennial meetings. The idea is that these meetings should allow geologists to come together to discuss a grand theme, relevant to both the host nation and to Europe as a whole, at reasonable cost.

Other major conferences and congresses take place in Europe, of course. One can think of the EUG Strasbourg Meeting, for example, or the biennial Geoscience meetings organized by the Geological Society of London. But MAEGS is the only meeting to unite European *societies*. And that, I believe, is very important for their future; and especially of those in the countries of the former Eastern bloc.

The AEGS has 33 members across the wider Europe. The meeting it organizes are always self-financing, so membership of the society is not a heavy financial burden upon those member societies. Indeed, according to its new membership criteria, it operates a three-band scale of membership dues, based on each society's membership numbers. Those who cannot afford to pay any fee at all can remain members; though their representatives at Executive Committee level will not have voting rights. This preserves the original motivating spirit of AEGS, which is *inclusive*.

The meeting in Karlovy Vary was universally agreed to have been one of the best ever, and to have left the Association in good shape. The scientific sessions focused on five areas: the geochemistry of mantle plumes; radiogenic dating; crustal rare-earth dynamics; enigmas of the Bohemian massif, and the use of isotopes in paleoclimate and environmental studies.

Mantle plumes were an appropriate sub-theme, since Karlovy Vary – according to one keynote address (by Dr. Marjorie Wilson of Leeds University, United Kingdom) is probably sitting on top of one. The local press, summoned to the conference to hear this fact sat in respectful silence as they were told their own town owed its historical and economic importance to a gigantic mushroom several hundred kilometers below their feet. It takes something to shock journalists at any time of day, let alone at 8:30 AM, and this did it.

MAEGS-10, of which this is the conference volume, was superbly organized and strengthened the Association immeasurably. The Association looks forward to its next meeting, in Spain, with renewed confidence and vigour.

Dr. Ted Nield FGS NUJ is Science & Communication Officer of the Geological Society of London.

Challenges to Chemical Geology: An Introduction

JEFF ROSENBAUM

Our knowledge of the Earth has expanded by orders of magnitude over the last half century, in large part due to the contributions of geochemistry. We now have data that bear on the age of our solar system; the time scales of tectonics, the temperatures of paleooceans, and even the existence of extraterrestrial life. A glance at the abstracts from the meeting from whence this special volume originates gives an idea of how large a range of topics is currently studied by geochemists – igneous petrogenesis; the timing and duration of tectonic events, crustal formation, deformation, and erosion; paleoclimate reconstruction; the fate of pollutants in the environment, etc. Geochemistry includes studies of the lithosphere, hydrosphere, atmosphere, and biosphere, and is ultimately concerned with understanding the behaviour and distribution of all the elements of the periodic table throughout the Earth. Virtually all aspects of the study of the Earth have been enhanced greatly by geochemical input.

By providing a method to determine both relative and absolute ages of samples, geochemistry has given the Earth Sciences a time scale. Geochemical studies have constrained the age of the Earth, the movement of tectonic plates, the speed of oceanic overturn, the recurrence interval of earthquakes, the time scale of climate change, the residence time of carbon in lakes... This list is virtually endless and continues to grow exponentially as new geochemical techniques are brought on line.

Tracer studies using stable and radiogenic isotopes continue to yield valuable information on both natural and anthropogenic systems. A knowledge of hydrogen and oxygen stable isotope behavior is an essential part of most research on the components of the hydrosphere. Carbon stable isotopes continue to be invaluable in studies of the interaction between biota and their environment. Igneous and metamorphic studies often rely on geochemical tracer data. Isotope methods are essential to current paleoclimate studies, often based on the accurate measurement and interpretation of stable isotope variations in natural materials through time. Both stable and radiogenic isotope tracers are being used in sediment provenance studies, so important to our understanding of paleoclimate systems. Isotopically-labelled compounds are routinely used as tracers in geochemical and biogeochemical experiments.

Chemical tracers are also finding their way into many current geochemical studies. The halogen elements are being used as indicators of seawater influence in igneous and metamorphic systems. The degradation of organic compounds is becoming more important to studies of climate change and evolution. The concept of molecular and elemental residence times is being applied to determine the rates and features of nutrient cycling in natural biosystems.

Established geochemical techniques are being used in novel ways. The same methods used to study mantle xenoliths are applied now to understanding river drainage basins. Novel geochemical procedures are continuously being developed, stretching the capabili-

ties of existing instrumentation and sometimes requiring the development of new machines. The evolution of new analytical tools has accompanied many important advances in geochemistry. Major strides in instrumentation allow ever more precise measurements on increasingly smaller sample sizes. These microanalytical developments are only beginning to be exploited, often providing more questions than answers while expanding our awareness of the complexity of geochemical processes.

As we enter the next century, geochemistry will play a constantly growing role in our lives as concerns about climate change, and environmental pollution become increasingly important to individuals and governments across the globe. Geochemists will need to use their skills to study these problems carefully and work toward finding their solutions.

Dr. Jeff Rosenbaum is a Senior Research Fellow of Geochemistry at the University of Reading, United Kingdom.

Rare earth elements and yttrium fractionation caused by fluid migration

PETER MÖLLER

GeoForschungsZentrum Potsdam, D-14473 Potsdam, Germany

Abstract: Two effects produce anomalies in REY patterns: (i) deviating oxidation states and (ii) differences in chemical bonds either on surfaces or in solution. Oxidation of Ce and reduction of Eu both lead to deviating ionic sizes with respect to their enclosing REE neighbours. Differences in solution and surface complexation of neighbouring lanthanides and between Y and Ho, although both latter ions are of equal charge and size, induce anomalous behaviour. These effects are enlarged by kinetic phenomena in dynamic systems due to which the lower charged and/or more strongly complexed ions in solution are less retarded by adsorption during migration through pores than the higher charged and/or less strongly complexed ones. Physicochemical considerations are discussed with the aim (i) to improve the understanding of why such anomalies occur and (ii) to quantify these effects.

Key words: REY, fluid movement, fractionation.

1. Introduction

Distribution of rare earth elements (REE) and yttrium (Y) is studied for two main purposes: (i) theoretical understanding of the systematically changing behaviour of a set of elements that are mainly trivalent and (ii) application of their fractionation as a geochemical probe to study minero-chemical processes in the Earth's crust. The first subject is delt with by theoretical chemists and physicists, whereas the latter is the unique goal of geochemistry. Since it has become an easy task to determine the abundances of REE and Y, the geochemical literature is flooded by papers using REE to characterise the source and development of rocks, minerals and fluids. Of particular interest are the anomalously behaving lanthanides and Y that yield further information on the process-controlling parameters.

The sequence of rare earth elements including yttrium (REY) is best suited for studying (i) the influence of the ionic size in solids and fluids (Fig. 1) and (ii) the effect of systematically changing electron configuration (Tab. 1) on ion distribution at constant charge. The well-known lanthanide contraction is less than the expected non-relativistic Bohr radii predict. The "transparent" *f* atomic orbitals screen the nuclear attraction only incompletely. Thus, a larger effective core