

# Prefaces

## **Preface from Her Excellency the Minister of Energy, Mines, Water and Environment, Director of ONHYM**

Due to its geological diversity, related to the succession of four geological cycles from the Archean to the Alpine Orogeny, and including the major Pan-African and Variscan cycles, Morocco has always been characterized by intense mining activity. The earliest mining works include the remains of exploitations at Imiter (Ag), Bleida (Cu), Zgounder (Ag), Iourirn (Au), Tazalaght (Cu) and have been dated from the 9th to 15th centuries. Today, Morocco is the world's leading exporter for phosphates and produces significant quantities of a wide variety of mineral resources such as silver, zinc, lead, cobalt, manganese, fluorite, barite, bentonite, etc.

The development of the Earth Sciences in Morocco undergone a surge of new activity during the last two decades, based on the diversity of its substratum and on the international achievements in this domain. This new impulse resulted in high level research programs in the frame of national and international partnerships, and in the launching of the National Plan for Geological Mapping aimed at providing a geological infrastructure to the country, and including geological, geophysical and geochemical mapping. This intense activity resulted in a better understanding of the geodynamic framework, based on a more precise stratigraphy and on the systematic use of seismic profiles, geophysical modelling experiments, and modern geotechnologies such as SHRIMP isotopic datings and fission track thermochronology.

It is precisely within this context that the work entitled *Continental Evolution: Geology of Morocco* is presented by Pr. A. Michard and an international, multidisciplinary team. This work follows an earlier book published by the same author in 1976 under the title "Éléments de Géologie Marocaine". As a specialist in tectonics, Pr. Michard is familiar with Moroccan geology. Since the early 70's, he has participated in the education of a number of Moroccan geologists, and today he continues to supervise theses and co-author papers on the geology of the country. In fact, two of his co-editors and several of his co-authors are former students of

him. Pr. Michard also supervises the mapping activity of geologists of the Ministry of Energy, Mines, Water and the Environment.

This new book provides an updated overview of the geological knowledge of Morocco based on the achievements of the last few decades. The authors pay homage to their predecessor's work with a large set of references providing a complete review and insight into the geology of Morocco. After an outline of the geological structure and evolution of the country, in the context of the African continent and peri-Atlantic plate tectonics, the book considers successively the Pan-African Belt with a refined geodynamic interpretation; the Variscan events in the Anti-Atlas and southern Morocco as well as in the Meseta Domain; the Atlas System, Rif Belt, Atlantic Basins and Mesetan and Saharan Plateaus, all of which developed during the Alpine cycle; and finally the Quaternary deposits.

We are convinced that this work will strengthen the position of Moroccan geology in the international community of geosciences. This book constitutes essential reading for operators in the sectors of mines, petroleum and the environment. It also provides key insights into the major problems of continental crust evolution from the Archean to the Present.

Prepared by a multi-disciplinary team of specialists in teaching and transfer of knowledge, this work will become the standard work for future generations of geoscientists seeking to understand the geology of Morocco.

We warmly congratulate the entire team of experts who undertook the realization of this work, and hope to see it distributed widely in Morocco and elsewhere.

*Amina Benkhadra*

## **Preface from the International Lithosphere Program**

Morocco constitutes a unique natural laboratory at the junction between the Atlantic margin, the Mediterranean and the African craton. There, long lasting interactions between mantle and lithosphere dynamics, crustal extension and compression, subsidence and uplift, can be documented in great detail using surface geological records preserved in synrift, postrift and foreland sedimentary series. Outcrops are excellent in the inverted basins of the Atlas, whereas most low lands and the offshore are covered by industry seismic profiles, which have been calibrated by numerous exploration wells.

In October 2007, the geology of Morocco has attracted the interest of more than 700 geologists coming from its conjugate margins in Canada and the US, from Spain, France and other European countries, as well as from other North African countries, all these earth scientists convening for an international meeting hosted by the MAPG, with a strong participation of the ILP Task force VI on Sedimentary Basins.

Morocco has become the focus of discussion for both the academic and industry international communities, which will strongly benefit from this updated compilation of the Moroccan geology. This new Springer volume, co-authored by 36

contributors from various Moroccan (Rabat, Casablanca, Kénitra and Marrakech) and European (Orsay, Cergy-Pontoise, Montpellier, Savoie, Toulouse, ENS-Paris, African Museum of Belgium, Neuchâtel, Granada) universities and the industry (ONHYM and OMV), comprises 10 chapters dedicated to the main geodynamic episodes which controlled the geology of the country, from the Precambrian and Paleozoic orogens to the Mesozoic rifting and subsequent episodes of basin inversion. We are grateful to the editors, André Michard and Dominique Frizon de Lamotte on one hand, and Omar Saddiqi and Ahmed Chalouan on the other hand, who are respectively two leading French and Moroccan experts of the geology of this part of the World, for having stimulated the contributions of such wide range of expertise, and to provide the international community with a very high standard, easy to read volume.

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## **Preface from the Société Géologique de France**

Morocco is the key point between one passive margin (Atlantic Ocean), one ocean acting to closure (Mediterranean) and an old craton (Africa). Showing Precambrian and Palaeozoic orogenies up to Mesozoic rifting and Cenozoic orogeny, Morocco is a fantastic place where geodynamic interactions between mantle and lithosphere are illustrated.

In this remarkable book which perfectly resumes the last discoveries and state of knowledge of Morocco geology, André Michard, Omar Saddiqi, Ahmed Chalouan and Dominique Frizon de Lamotte, together with a wide panel of specialists, are offering us the “field verity” that is to say, the results of observation and cartography synthesis. These discoveries and state of knowledge have been exposed in the October 2007 International Congress of Marrakech organized by MAPG and ILP, and followed by seven hundreds people coming from either academic or professional world. The authors and contributors of the present book were the leaders of most of the field trips related to the congress.

Since the time of the pioneers of the geological discovery of Morocco (A. Brives, L. Gentil, L. Neltner and others), the Société géologique de France has published hundreds of papers and a number of memoirs concerning the geology, paleontology or mineralogy of Morocco, and its Bulletin remains one of the traditional tribunes for Moroccan publications. Let us also recall the “Réunion Extraordinaire” of the SGF at Rabat, 1973, dedicated to the Gibraltar Arc.

Today, it is a great honour for the Société géologique de France to support the publication and diffusion of such a very high standard volume.

*Christian Ravenne and André Schaaf*

President and First Vice-President of the Société Géologique de France



Continental Evolution: The Geology of Morocco  
Structure, Stratigraphy, and Tectonics of the  
Africa-Atlantic-Mediterranean Triple Junction

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Lamotte, D. (Eds.)

2008, XVIII, 426 p. 235 illus. in color., Hardcover  
ISBN: 978-3-540-77075-6