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The Geology of the Arab World—An Overview

Springer

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To My late Father, Prof. Mohamed Bendaoud, who gave me the curiosity to try to understand the universe.

To my daughter, Maya Ines and my son Rostom with whom I share this passion.

Abderrahmane Bendaoud

To my family: my wife, my children and my grandchildren.

Mohamed Hamoudi

To my wife, my three children and my parents.

Safouane Djemai

Preface

April 2013, the Arabian Geosciences Union (ArabGU) has been established, as a nonprofit international association, similar in scope to the European Geosciences Union (EGU), the American Geophysical Union (AGU), the Japanese Geosciences Union (JpGU), and the Asia Oceania Geosciences Society (AOGS). ArabGU aims to promote, disseminate, and contribute to geosciences as a whole, with emphasis on the Arab World, through organizing an annual international meeting bringing distinguished scientists and professionals together to discuss topics of broad interest. February 17–22, 2016, the first ArabGU International Congress (AIC-1) was co-organized by ArabGU, the University of Science and Technology Houari Boumediene (USTHB), the Center for Research in Astronomy, Astrophysics and Geophysics (CRAAG) and the Algerian Society of Geophysics (SAG). More than 150 participants from 15 Arab and Western countries (Morocco, Algeria, Tunisia, Egypt, Sudan, Yemen, the Emirates, Libya, Canada, Spain, France, Italy, Austria, Japan) have taken a part in this international event. The topics covered include structural geology, tectonics, remote sensing, GIS, stratigraphy, seismology, metallogeny, Precambrian geology, Phanerozoic geology, geophysics and modeling, planetology and geoheritage, along with many other multidisciplinary items. This book is the result of the work of this first international congress of the ArabGU.

From the geological point of view, Arab region (13,132,327 km^2) is dominated by a wide variety of lithologic units ranging from Archean to Quaternary. Since the amalgamation of Gondwana, this region formed a continuous ensemble consisting of Archean and/or Palaeoproterozoic cratonic terranes and Neoproterozoic Pan-African belts surrounded by Paleozoic basins. It was affected to a greater or lesser extent by various Phanerozoic Caledonian, Hercynian, and Alpine orogeneses. The countries of the Arab world also have the particularity to have their economic growth mainly driven by exports to the world market of hydrocarbons (oil and natural gas) and mineral resources or by tourism thanks in particular to their geoheritage.

This book, comprising 14 chapters, is aimed at readers who are already familiar with the Geology of the Arab Region. Some chapters are research articles and others are reviews that embrace a wide range of Earth sciences. The volume as a whole represents a valuable basic reference for junior/senior geoscientists who are keen interest with the aspects to be addressed.

In Chapter "Tectonics of the Eastern Desert of Egypt: Key to Understanding the Neoproterozoic Evolution of the Arabian–Nubian Shield (East African Orogen)", Hamimi et al. highlighted the tectonic setting of the Egyptian Nubian Shield in an attempt to decipher the Neoproterozoic tectonic evolution of the Arab-Nubian Shield and the entire East African Orogen.

In the next contribution, Liégeois presents and discusses his geological map of the Tuareg Shield map that served as the basis for this region in the new 1/10,000,000 scale geological map of Africa (BRGM, 2016). It synthesizes all the knowledge acquired to date on this Shield, and to which the author has greatly contributed through his work over the past 30 years. It differentiates between terranes whose ages may be Archean, Paleoproterozoic or Neoproterozoic and the orogenic events that affected them during the Paleoproterozoic or the Neoproterozoic. This chapter also proposes a global evolution model for the amalgamation of these terranes during the Pan-African.

Chapter "The 600 Ma-Old Pan-African Magmatism in the In Ouzzal Terrane (Tuareg Shield, Algeria): Witness of the Metacratonisation of a Rigid Block", is a discussion given by Fezaa et al. on the geochronological, geochemical and isotopic characteristics of Pan-African granitic plutons intruding the Archean-Paleoproterozoic terrane of In Ouzzal in the Hoggar Shield (Algerian part of the Tuareg Shield). The authors indicated that this pluton was formed by a process of metacratonization of an old lithosphere at a late stage of the Pan-African Orogeny.

Chapter "An Overview of the Plutons Magnetic Fabric Studies in the Hoggar Shield: Evolution of the Major Shear Zones During the Pan-African", by Henry et al., is essentially a synthesis of their work on magnetic fabrics obtained on different granitic plutons of the Hoggar Shield. The authors highlighted different stages of the Pan-African Orogeny, responsible for deformation along megashears traversing the shield. Changes in the direction of continental convergence during the Pan-African Orogeny are also dealt with in this chapter.

Chapter "Electrical Conductivity Constraints on the Geometry of the Western LATEA Boundary from a Magnetotelluric Data Acquired Near Tahalgha Volcanic District (Hoggar, Southern Algeria)", by Bouzid et al., is a magnetotelluric study that attempts to constrain the geometry of the lithosphere in a key region of the Hoggar Shield. The region encompasses a shear zone separating the archean-paleoproterozoic terranes of the central Hoggar from the Neoproterozoic juvenile terranes of the western Hoggar.

Chapter "Regional Geology and Petroleum Systems of the Main Reservoirs and Source Rocks of North Africa and the Middle East", by Lučić and Bosworth, presents various paleomagnetic studies carried out on the western Saharan basins

allowing the determination of the position of several paleomagnetic poles mainly between the Bashkirian and the Autunian and between the Middle Triassic and the Lias. Results indicate a post-Lias regional tectonics affecting the Paleozoic coverage of these basins.

In the next chapter, Lučić and Bosworth provide a remarkable and very edifying review of the major regional geological events that contributed to the genesis of large hydrocarbon fields in North Africa and Arabia. This is achieved in particular by high-quality illustrations that synthesize a large amount of information. In particular, they highlight the similarities that existed over geological time in this vast region as it evolved as contiguous parts of Gondwana.

In Chapter "Archaeoseismology in Algeria: Observed Damages Related to Probable Past Earthquakes on Archaeological Remains on Roman Sites (Tel Atlas of Algeria)", Deroin outlines of the main applications of satellite sensors in geological mapping, tectonics and structural geology, hydrogeology, mining geology, geoarchaeology, oil and gas exploration, earthquake and seismicity, landslides, and coastal erosion. He attested that remote sensing techniques are particularly suitable for geological studies in arid regions, such as the Arab world. Three examples of very different applications all located in Arab countries are given in this chapter.

Chapter "A Glimpse at the History of Seismology in Algeria", by Harbi et al., represents the first attempts to discuss the archaeoseismology in Algeria at the international scale. The authors demonstrate that the seismically active Tellian Atlas of Algeria preserves numerous archaeological evidence of ancient earthquakes ranging from the Roman period (BC 146–429) to the Vandal and Byzantine period (AD 429–533). They interpret damage to some monuments as being caused by strong earthquakes or landslides.

Chapter "Active Tectonics and Seismic Hazard in the Tell Atlas (Northern Algeria): A Review", by Maouche et al., is a contribution to the knowledge of the history of seismology in Algeria. The authors, after having inventoried what we know about the great seismic events in Algeria during the Middle Ages until the French colonization, which are very little documented, show the different stages of the evolution of seismology during the colonial period in Algeria, with notably the creation of the Algiers observatory and the first studies and measurements of seismic activity. Then, the postindependence period is detailed with the creation of the CNAAC (currently CRAAG). The authors have taken this opportunity to highlight the mastery and great scientific qualities of Algerian actors, during this period, in the field of seismology.

In Chapter "Seismicity of the Algerian Tell Atlas and the Impacts of Major Earthquakes", Ousadou and Bezzeghoud review the active tectonics and seismic hazard in the Tellian Atlas of Algeria, which has experienced several destructive earthquakes in the past. The authors note that seismicity is not randomly distributed but directly related to active geological structures, which correspond mainly to faulted folds. They also show the fundamental role of studies on the El Asnam and Zemmouri faults at the source of two of the most destructive earthquakes known in Algeria, in understanding seismogenic active tectonics in the region.

In the next Chapter "An Overview on 40 Years of Remote Sensing Geology Based on Arab Examples", Deroin, appraise the seismicity in northern Algeria and carry out a detailed analysis of the main earthquakes that have occurred in the Tell Atlas since 1980. Throughout this revision, the authors characterize the impacts of several major earthquakes that occurred between 1364 and 2015 in terms of seismic energy.

Chapter "Meteorite Impact Structures in the Arab World: An Overview", by Chabou, records the confirmed, proposed, or refuted impact craters in the Arab countries. The author did not just present a bibliographical work but he also combines it with the examination of satellite images and a critical synthesis of available geological, petrographic, and geochemical data. He proposes certain structures that could be affiliated to impact craters. Moreover, he came to the conclusion that the assessment of impact structures in the Arab region is still incomplete, given the large size of the territory and the low concentration of confirmed structures compared to other better studied regions.

In the last Chapter "Holocene Climate Development of North Africa and the Arabian Peninsula", Lüning and Vahrenholt examine the hydroclimatic and temperature changes in the Arab region over the past 15,000 years by correlating and integrating all available case studies. The authors describe the passage of a wet green Sahara, between 15,000 and 9000 years BP, under conditions currently 6500–3500 years BP, depending on the regions. They suggest that the Holocene climate history of North Africa and Arabia is closely linked to global development and that significant temperature changes have also occurred in subtropical climate belts.

In conclusion, we would like to express our thanks to the contributors who provided manuscripts to this textbook. We are also indebted to the following list of reviewers (arranged in alphabetical order) for their valuable comments and constructive criticism.

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