World Geomorphological Landscapes

Nabil Sayed Embabi

Landscapes and Landforms of Egypt

Landforms and Evolution

Springer

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This book is dedicated to all Earth Sciences Students and Researchers

Series Editor Preface

Landforms and landscapes vary enormously across the Earth, from high mountains to endless plains. At a smaller scale, Nature often surprises us creating shapes which look improbable. Many physical landscapes are so immensely beautiful that they received the highest possible recognition—they hold the status of World Heritage properties. Apart from often being immensely scenic, landscapes tell stories which not uncommonly can be traced back in time for tens of million years and include unique events. In addition, many landscapes owe their appearance and harmony not solely to the natural forces. Since centuries, or even millennia, they have been shaped by humans who modified hillslopes, river courses, coastlines, and erected structures which often blend with the natural landforms to form inseparable entities.

These landscapes are studied by geomorphology—"the Science of Scenery"—a part of Earth Sciences that focuses on landforms, their assemblages, surface and subsurface processes that molded them in the past and that change them today. Shapes of landforms and regularities of their spatial distribution, their origin, evolution, and ages are the subject of research. Geomorphology is also a science of considerable practical importance since many geomorphic processes occur so suddenly and unexpectedly, and with such a force, that they pose significant hazards to human populations and not uncommonly result in considerable damage or even casualties.

To show the importance of geomorphology in understanding the landscape, and to present the beauty and diversity of the geomorphological sceneries across the world, we have launched a new book series *World Geomorphological Landscapes*. It aims to be a scientific library of monographs that present and explain physical landscapes, focusing on both representative and uniquely spectacular examples. Each book will contain details on geomorphology of a particular country or a geographically coherent region. This volume presents geomorphology of Egypt—a country widely known for their archaeological heritage but much less for its outstanding geomorphology. The physical environment of Egypt is usually seen from the perspective of the Nile, its floodplain and its delta, whereas the rest is "just desert." This volume, while inevitably considering the Nile and the Delta in detail, also demonstrates the huge diversity of desert landscapes on both sides of the Nile and in the Sinai Peninsula. It also shows the variety of coastal features along both long coastlines that Egypt has—along the Mediterranean Sea and the Red Sea. More importantly, however, the reader will have the chance to virtually visit remote desert landscapes which are hardly accessible and few geomorphologists enjoyed being there in person.

The World Geomorphological Landscapes series is produced under the scientific patronage of the International Association of Geomorphologists—a society that brings together geomorphologists from all around the world. The IAG was established in 1989 and is an independent scientific association affiliated with the International Geographical Union and the International Union of Geological Sciences. Among its main aims are to promote geomorphology and to foster dissemination of geomorphological knowledge. I believe that this lavishly illustrated series, which sticks to the scientific rigor, is the most appropriate means to fulfill these aims and to serve the geoscientific community. To this end, my great thanks go to Professor Nabil Sayed Embabi for undertaking this enormous task, to produce the

geomorphological synthesis of his country as a single-author volume. His many years of experience in researching Egyptian landscapes, from the coast to the heart of the Sahara, culminated in this comprehensive account of the fascinating morphology of Egypt that is now presented to the international geomorphological community.

Wroclaw, Poland Piotr Migoń

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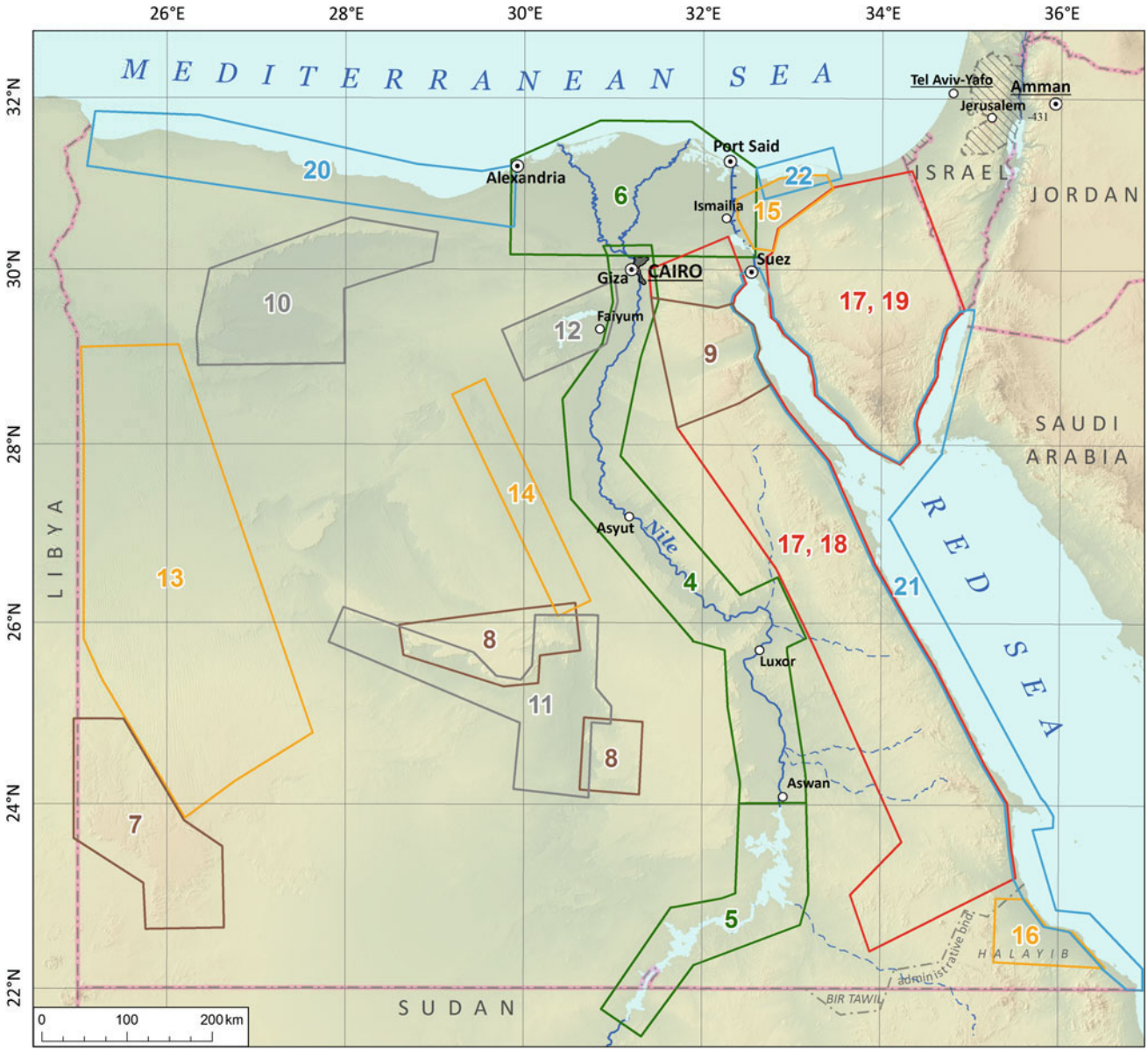

Fig. 1 Location of areas covered by each chapter (numbers of chapters are indicated in each box)

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About the Author

Nabil Sayed Embabi has been a Professor of Desert Geomorphology in the Department of Geography, Faculty of Arts, Ain Shams University, Cairo, Egypt since 1979. He obtained his Ph.D. from Bristol University, UK in 1967. Dr. Embabi has taught at several Arab Universities: King Abdel-Aziz University at Jeddah (1972), Libyan University at Tripoli (1973), Qatar University at Doha (1979-1983), and the United Arab Emirates University at Al-Ain (1988–1992). During his research spanning over 50 years, he participated in or led a number of expeditions or research projects in Egypt/Arabian Deserts. He has also been involved in scientific collaboration with professors at universities in the United States of America, Finland, and the United Kingdom. He has authored and coauthored more than 50 papers and four books in English/Arabic, and attended and presented papers at several international conferences such as those of the International Geographical Congress and the International Association of Geomorphologists. His research papers were cited 87 times in previously published scientific work according to Academia.edu.

Introduction

This book is an attempt to introduce the landscapes and landforms of Egypt to the Earth Scientists. This country has a huge wealth of landforms and landscapes which were inherited from the past geological periods. Some of these inherited forms developed more than 500 Ma ago, influenced by the past (arid and wet) climates. This huge legacy deserves to be presented to scholars of Earth Sciences. For limitations of space and scope, this book does not claim to cover every landform. However, it deals with all types of landscapes and landforms, selecting representative examples or, which have never been studied. Landscapes and forms in this book depend on three sources of data. First, field observations and studies conducted over a span of more than fifty years; some of the field photographs included in this book are taken in the late fifties and early sixties of the twentieth century. Second, previous geologic and geomorphologic studies published in scientific journals/books, as well as unpublished scientific dissertations (both on the masters and on the doctoral level). The third source of data is the space images of Google Earth and Landsat-TM images, aerial photographs, and topographic and geologic maps. The availability of high-resolution images on the Internet through Google Earth made it possible to discover and study some forms—which would have otherwise been an impossible task without such images.

This book is divided into 24 chapters, grouped into eight parts. **Part I** presents the general characteristics of Egypt: Chap. 1 covers the geographical regions of Egypt, Chap. 2 presents the geologic setting of Egypt, and Chap. 3 addresses the past and present climatic conditions. **Part II** deals with the Nile in Egypt and is divided into three chapters: Chap. 4 presents major and remarkable events which occurred during the life of the Nile, Chap. 5 deals with Lake Nasser, and Chap. 6 analyzes the geomorphic aspects of the Nile Delta. **Part III** deals with some selected representative plateaus that are either typical or unique in their geologic and geomorphic aspects. Here, the sandstone plateaus in the SW of the Western Desert of Abu Ras and the Gif Kebir (Chap. 7), the vast karstified plateau between the Nile Valley and the mega-depressions (Chap. 8), and the two Galalah plateaus in the Eastern Desert (Chap. 9) are selected. **Part IV** tackles the depressions in the Western Desert, of which three are selected. These three depressions are the Qattara, which is the largest and deepest one (Chap. 10), the Kharga-Dakhla representing such depressions developed in the leeward side of cuesta escarpments (Chap. 11), and the Fayum Depression due to its unique connection to the Nile Valley (Chap. 12).

In **Part V**, four sand seas and three dune fields are selected out of 16 seas and fields in Egypt. The Great Sand Sea is the largest (>100,000 km^2) in Egypt (Chap. 13). Contrary to it, dune fields in SE of Eastern Desert are the smallest fields in Egypt (a few hundred square kilometers) which are presented in Chap. 16, and have been examined for the first time in detail with the aid of Google Earth images. In fact, study of dune fields in SE of the Eastern Desert would not have been possible without the high-resolution images of Google Earth. The Ghard Abu Moharik Sand Sea, however (Chap. 14), is an exceptional sand sea—not only in Egypt, but also in other deserts—because of its linearity. The North Sinai Sand Sea (Chap. 15) covers the north Sinai plains between the coastal strip and the Syrian Arcs. It is one of the most complex sand seas in Egypt. **Part VI** (Mountains and drainage systems) is divided into three chapters. Chapter 17 deals with the Red Sea and Sinai Mountains; Chap. 18 addresses the drainage system of the Red Sea Mountains, whereas Chap. 19 analyzes the Sinai drainage system. **Part VII** covers the coastal forms: It is divided into three chapters. Although they are

small forms, the carbonate ridges of the northwest coast of the Mediterranean Sea make a characteristic rolling landscape in this coastal region and are tackled in Chap. 20. The Red Sea and Sinai coasts have a wealth of forms, because they are the location where several continental and marine processes meet together along the coastal fringes (Chap. 21). The Bardawil is one of the unique lagoons on the Mediterranean coasts since it has a tectonic origin and it has no connection to the Nile water unlike other large lagoons, and it is dealt with in Chap. 22. **Part VIII** examines Geo-Parks and geomorphologic hazards. Selected Geo-Parks and some specific forms are presented in Chap. 23, because of their characteristic forms/landscapes. Finally, it was seen appropriate to conclude this book with a presentation of the most recurring geomorphologic hazards in Egypt (Chap. 24).

Part I
General

Geographic Regions of Egypt

1

Abstract

This chapter presents the main characteristics of the four geographic regions of Egypt. Since it runs in a north–south direction, the Nile Valley divides the Egyptian landmass into two vast regions: one in the west, and the other one in the east. The one in the west is called the Western Desert, and the one in the east (except for the Sinai Peninsula) is called the Eastern Desert. Although some landforms are repeated in more than one region, every region has its own landscape that makes it different from others. This means that Egypt is divided into four geographic regions: the Nile Valley, the Western Desert, the Eastern Desert, and Sinai Peninsula. Characteristic forms of each region are presented to draw a clear and accurate picture for each one of them, but also of the whole of Egypt. Furthermore, this analysis will serve as an introduction to the detailed geomorphic studies that will follow in this book.

Keywords

The Nile Valley • The Nile Delta • The Western Desert • The Eastern Desert • Sinai Peninsula • The Mediterranean Sea • The Red Sea

1.1 Introduction

Egypt, or *Misr*, occupies the north–eastern corner of Africa and extends beyond the Isthmus and Gulf of Suez into Asia to the Sinai Peninsula. It lies approximately between latitudes 22° and 32° N, and longitudes 25° and 37° E. Its maximum width from east to west is about 1230 km, and its maximum length from north to south is about 1100 km. Egypt covers an area of approximately 1 million km^2 and takes, to a large extent, the neat form of a square. Egypt is bound by the Mediterranean Sea to the north, the Republic of the Sudan to the south, the Republic of Libya to the west, and the Red Sea, the Gulf of Aqaba, and Palestine/Israel to the east. Since the Tropic of Cancer crosses the southern part of the country, Egypt lies in the tropical and subtropical arid climate. It forms the eastern part of the Sahara and forms a part of the great desert belt, which extends from the African Atlantic coast in the west, to Arabia and Iran in Asia in the east.

Egypt is divided into four geographic regions. These regions are the Nile Valley and the Delta, the Western Desert, the Eastern Desert, and the Sinai Peninsula (Fig. 1.1). **The Nile Valley and the Delta** represent a unique feature, not only in Egypt but also in the north of Africa. The **Western Desert** is dominated by plateaus, sand dunes, and depressions, whereas the **Eastern Desert** is the region of mountains, which dominate the landscape from north to south. **Sinai** is a characteristic triangular-shaped region and

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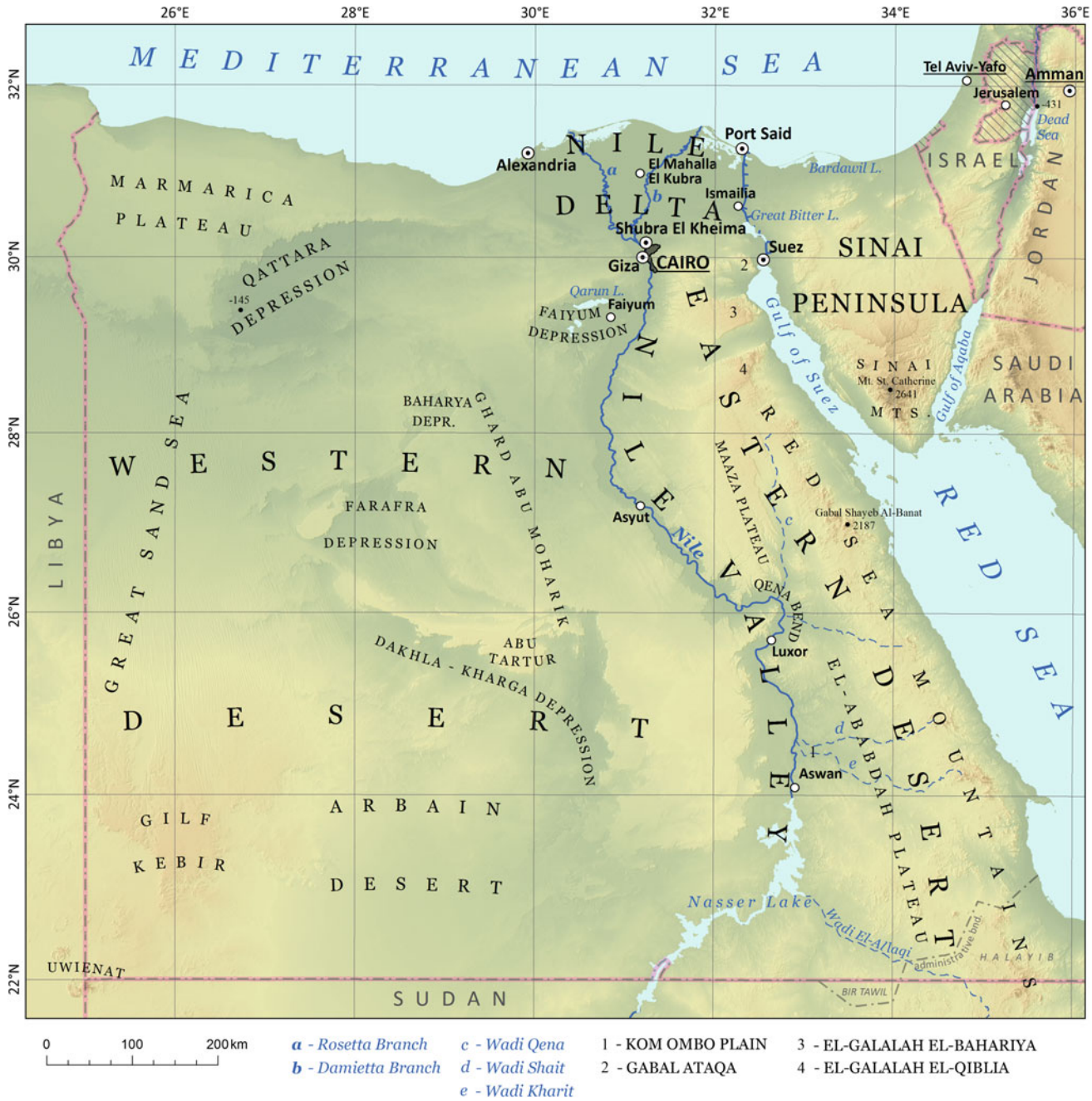

Fig. 1.1 Map of Egypt showing the geographical names mentioned in the text

is bound by water bodies along long stretches in all directions. Furthermore, in order to understand the geomorphology of Egypt, it is useful to note that the Mediterranean and the Red Seas are as important as those four regions. This chapter summarizes the main geomorphologic aspects of each region.

1.2 The Nile Valley and the Nile Delta

The **Nile Valley** and the **Nile Delta** constitute the smallest region in Egypt. They cover about 3.5% (35,000 km^2) of the total area of the country. As a perennial stream running in a desert region, the **River Nile** is a salient feature in the

geomorphology of Egypt. Not only does it divide the country into two distinct physical regions (the Western and Eastern Deserts), but it has also shaped Egypt's history and human occupations. The Nile in Egypt represents the terminal 1530 km of the River Nile, which extends for about 6825 km. Its level decreases from 114 m above sea level (asl) at the Egyptian-Sudanese borders, to 84 m asl at Aswan, to 18 m asl at Cairo. Along this distance, it receives no water from any of its tributaries. During its geological history, the Nile developed a valley and formed a delta.

The Nile Valley widens gradually northwards from several hundreds of meters in the south to 23 km at the latitude of Beni Suef city ~122 km to the south of Cairo. To the south of the First Cataract, about 60 km south of Aswan, the Nubian Nile used to pass through a very narrow valley, which was surrounded by cliffs from both sides. At present, this reach is drowned by the waters of Lake Nasser, which came into being after the construction of the High Dam in the late 1960s of the twentieth century. The total length of **Lake Nasser** at 180 m is about 500 km from Aswan to Dal Cataract in the Sudan. Due to previous topography, the width of the lake varies greatly from place to place with a general mean of 12.5 km. The mean gradient of the Nubian sector is 1/11,000. In the north of Aswan, the flood plain broadens gradually except for certain sections where the plain disappears such as the case with the Silsila gorge (60 km north of Aswan). At about 300 km north of Aswan, the Nile makes a large and abrupt bend known as the **Qena Bend**, which is bound by high and steep limestone sides rising up to 300 m asl. The eastern side of the Nile Valley from Aswan to Cairo is generally higher and steeper than the western side (Fig. 1.2). Most of the important wadis, which were former tributaries to the Nile, come from the eastern side of the Valley. However, the sides of the Nile Valley rise up to the level of the surrounding plateaus, which are 200–400 m a.s.l. Along this distance (1100 km), the Nile occupies the eastern side of its floodplain. In some instances, the Nile abuts on the base of the eastern side. The width of the Nile channel varies between 300 m in El-Silsila Gorge and 4–5 km in various parts from the Qena Bend to the apex of the Delta to the north of Cairo.

Parallel to the River Nile, at the western margins of the floodplain, a meandering channel called **Bahr Youssef**, branching at Dyrut (a town 300 km to the south of Cairo) from the Ibrahimiya irrigation canal, flows northward. At the latitude of Beni Suef city, this channel changes its

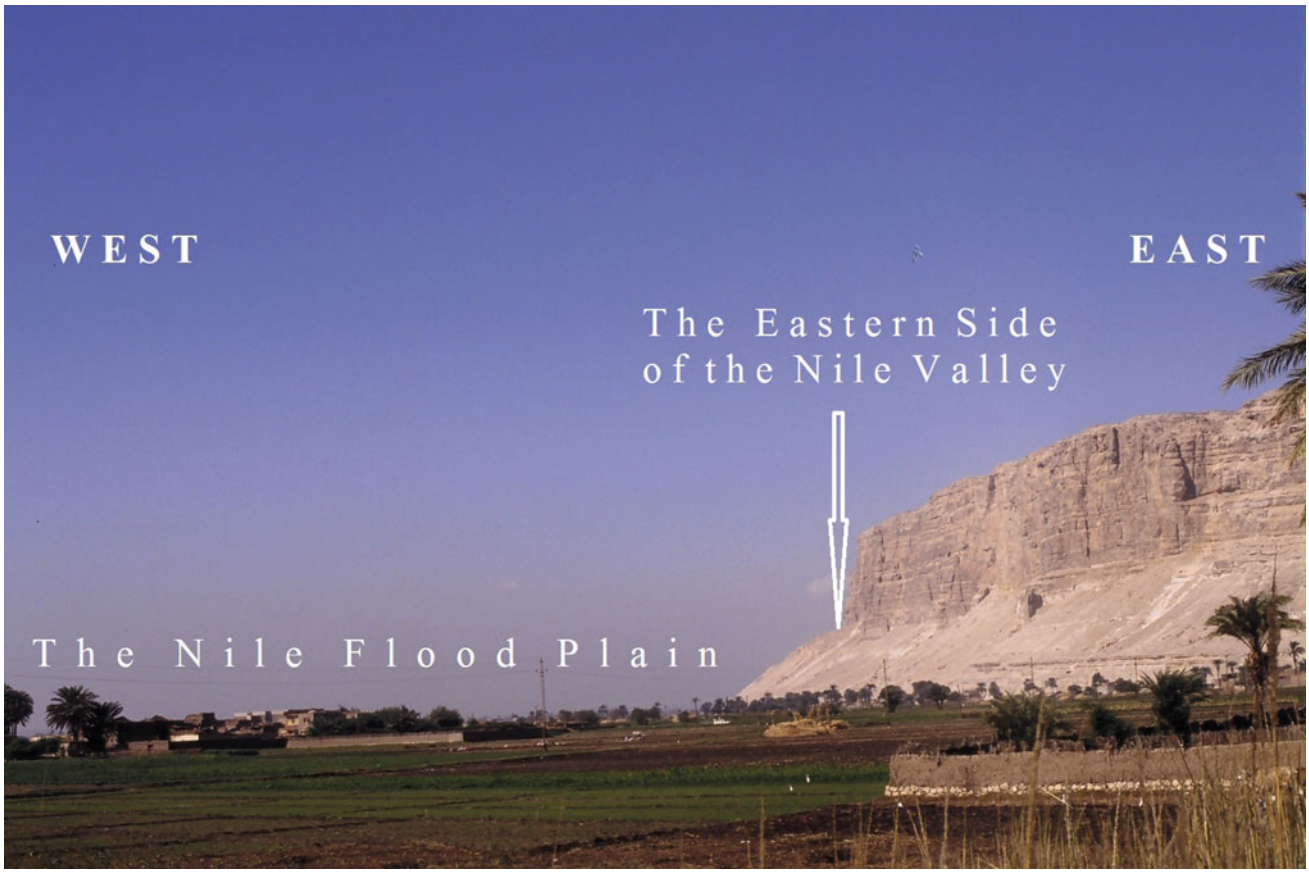

Fig. 1.2 Nile floodplain and the eastern side of the Nile Valley in the vicinity of Asyut city

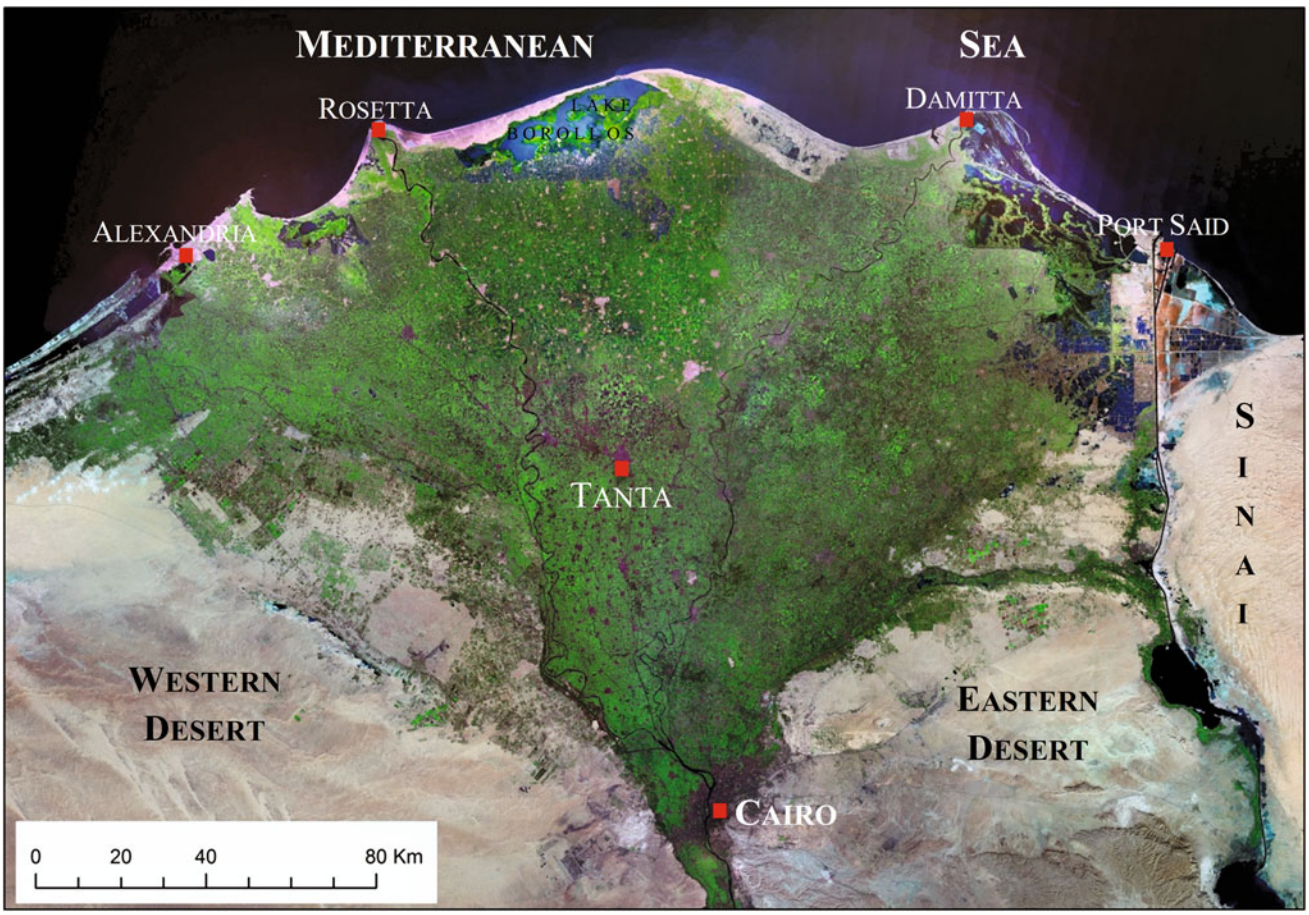

Fig. 1.3 Nile Delta with its triangle shape. (*Source* Google Earth 2012)

destination to the west and cuts through the divide separating the **Fayum Depression** from the Nile Valley. When entering the Depression, Bahr Youssef branches into various canals to irrigate the fertile lands at its floor. Excess irrigation water drains into two internal basins. The first is the **Qarun Lake**, which occupies the lowest part of the Fayum Depression (45 m below sea level), whereas the second is the **Wadi El-Rayan Depression**, lying to the west of Fayum. After the artificial connection with the Fayum drainage network in 1973 (Hamdan 1980), two small lakes were formed in Wadi El-Rayan.

In the north of Cairo, the **Nile Valley** opens up to the Nile Delta (Fig. 1.3). Due to its shape, the **Nile Delta** was the first of its kind to be named as such by Herodotus in 450 BC, when he visited Egypt and realized the great similarity between the shape of the Greek letter Δ and the shape of the Nile Delta. Before splitting into two branches, the Nile flows for about 20 km in the direction of north–west. The eastern branch of the delta is called **Damietta Branch**, whereas the western one is called **Rosetta Branch**. Those two branches are the last of several others, which have recently disappeared. The channels of these two branches, like that of the main Nile, are all characterized by meandering and the presence of silt islands, which total more than 400 islands in both the main Nile and its two branches (Taha 1997). The Delta is a vast depositional plain formed by the Nile a long time ago. The gradient of this deltaic plain is about 1/10,000. Along the Mediterranean coast, several shallow lagoons (Maryut, Idku, El-Brollos, and Manzala) were developed. These lagoons are connected to the sea by small openings (locally known as Bogaz) in the sand barriers, which separate them from the sea. They are kept open by artificial dredging since they represent good fisheries.

1.3 The Western Desert

The **Western Desert** is the largest geographic region in Egypt covering more than two-thirds of the total area of Egypt (681,000 km^2). The Western Desert is the region of plateaus, depressions, sand dunes, and plains. It is also a region of desert oases, which depends on the underground water of the Nubian aquifers. Except for the south–western part of the **Gilf Kebir** and **Uwienat**, which rises in some

places to more than 1000 m a.s.l, most of the Western Desert does not rise more than 300–400 m a.s.l (Fig. 1.1). Meanwhile, there are several localities in this desert lying below sea level (Fig. 1.1). The deepest point is −134 m (Ball 1927) to −145 m (IGN/SFS 1977) in Qattara Depression. Other areas are **Siwa** (−18.5 m), **Fayum** (−45 m), **Wadi El-Natrun** (−24 m), and **Wadi El-Rayan** (−64 m).

The southern part of the Western Desert is a vast plain bound to the north by the Kharga-Dakhla Depression, in the west by the Gilf Kebir Plateau, in the east by the Eocene plateau and the Nile Valley, and extends southwards into northern Sudan. This plain is called the **Arbain Desert** (or the Forty's Desert by Haynes 1982) after the well-known caravan route Darb El-Arbain, which crosses the middle area of this plain. Fig. (1.4) shows a camel caravan on this Darb El-Arbain dating to September 1978, photographed by the author while participating in a joint expedition of Ain Shams University, the Geological Survey of Egypt and the Smithsonian Institution of Washington DC. Most of this plain rises 150–200 m asl, but generally gets higher westward until it reaches 600 m asl on average at the foot slopes of the Gilf Kebir Plateau. Vast areas of this plain extend northward and merge into the floors of Abu Minqar, Kharga-Dakhla Depression. Toward these depressions, the level of the ground decreases gradually, where in some localities in Kharga, it reaches just a few meters above sea level. Hills in the depression, such as Gabal Edminston in Dakhla, and Gabal Taref, Gabal El-Ter, Gabal Um El-Ghanaiem, and Gabal El-Qarn in Kharga, may rise up to 100–300 m asl. Dunes spreading in these depressions are organized as dune belts (Fig. 1.5). Barchans moving southward under the effect of northern winds represent a permanent hazard for highways, farms, wells, and villages (Embabi 1982, 1990). Recently, buried wadis and channels were discovered by Radar Imaging by Columbia Shuttle in 1981. This paleo-drainage is known in previous studies as **Radar Rivers**, Subsurface Valleys, and Paleochannels (McCauley et al. 1982). The detailed picture of these wadis is still incomplete, since imaging has not covered the whole buried drainage net(s).

The escarpments of the depressions of Kharga-Dakhla and Abu Minqar represent the southern edges of the vast limestone and chalk plateaus, known as the karstified Eocene plateaus dominating the central part of the Western Desert. These plateaus extend eastward to the Nile Valley, westward to the Great Sand Sea, and northward to Siwa, Qattara, and Fayum depressions. Only the small plateaus of **Abu Tartur** and **El-Quss Abu Said** carry names. The maximum height attained by these plateaus is about 500 m asl in Abu Tartur Plateau, whereas the dominant height is 300–400 m asl. However, height decreases westward toward the Great Sand Sea, indicating the presence of a great basin occupied by the **Great Sand Sea**, since the same happens in north of the Gilf Kebir Plateau. A similar basin occupied by a small sand sea is present in the eastern part of **Farafra Depression**. The dominant features on the surfaces of these plateaus are sand seas and dune belts, small closed depressions, and relict karst forms. **Ghard Abu Moharik Sand Sea**, which extends for about 300 km from the northeast of **Bahariya Depression** to the northern escarpment of Kharga, represents a

Fig. 1.4 Camel caravan on Darb El-Arbain in the southern part of the Western Desert. (*Photo* taken in Sept. 1978)

Fig. 1.5 Dunes descending the Dakhla escarpment, forming a barchan belt in the Dakhla lowland

characteristic feature on this plateau. Bahariya and Farafra Depressions also characterize this central part of the Western Desert.

The Great Sand Sea is a salient feature in the Western Desert, extending for about 600 km from the northern escarpments of the Gilf Kebir and Abu Ras plateaus in the south to the southern margins of Siwa Depression in the north (Fig. 1.1). In addition to the evidence mentioned in the previous paragraph, which shows that this sand sea occupies a huge basin, other evidence indicates that the floor of its northern part approaches sea level or lies below it (Embabi 1998). Although the linear dune form is predominant in the Great Sand Sea (Fig. 1.6), its pattern changes from network to parallel and *Y*-junction from north to south. This sand sea represents the main source of sand, which forms the small dune field that extends from the south of the Gilf Kebir Plateau to Uwienat and north–west Sudan. Several kilometers to the south of Gilf Kebir, there is a small and unique plateau (47 km N–S, 25 km E–W maximum width). Its uniqueness comes from it being a peneplained plateau and is composed of igneous and metamorphic rocks. Heights range between 850 and 950 m a.s.l, with a single peak reaching 1114 m a.s.l.

The northern part of the Western Desert is dominated by the five major depressions of Siwa, Qattara, Wadi El-Natrun, Wadi El-Rayan and Fayum, and by the Miocene (Marmarica) plateau. As mentioned in Sect. 1.2, Bahr Youssef connects the Fayum Depression with the Nile Valley. This is why it is the only depression that has soils similar to those of the Nile Valley and is irrigated and cultivated by the Nile water. The floors of these five northern depressions are below sea level. The **Qattara Depression** is the largest (45,000 km^2) and the deepest (−145 m) erosional depression not only in Egypt but in Africa as well. The north–eastern escarpment of Qattara is only 60 km away from the Mediterranean coast, and this is why it was suggested by Ball (1927) to utilize this depression in the production of hydroelectric power by connecting it to the Mediterranean Sea through an open canal and a tunnel.

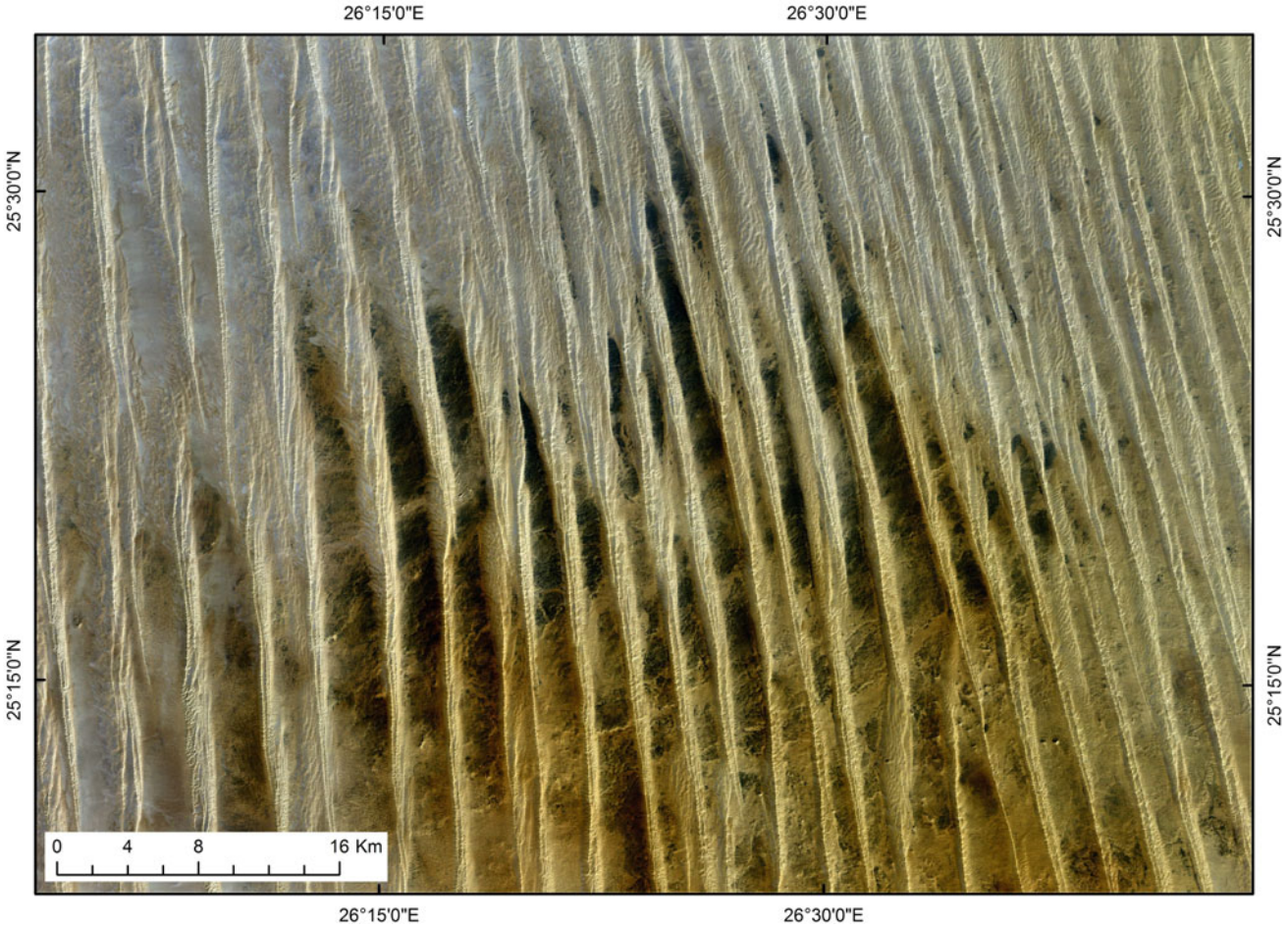

Fig. 1.6 Parallel linear dunes of the central section of the Great Sand Sea. (*Source* Google Earth 2012)

To the north of Qattara and Siwa, a vast Miocene limestone plateau extends to the coastal plain along the Mediterranean coastline, locally known as **Marmarica** or **El-Diffa Plateau**. This plateau rises 200–250 m a.s.l and is dotted by numerous small closed basins. A narrow coastal plain with a sequence of low **carbonate ridges** (bars) which are roughly parallel to the present coastline separates this plateau from the Mediterranean coast. This coastal plain opens up at a point to the south of Alamain and widens gradually eastward until it merges with the sandy plains of the western margins of the Nile Delta.

1.4 The Eastern Desert

This region occupies about one-fourth (225,000 km^2) of the total area of Egypt. It is bound by the Nile Valley and the Delta from the west, the Red Sea, the Gulf and Isthmus of Suez from the east, and the Egyptian-Sudanese border from the south. This is the region of mountains, plateaus, and large wadis. In this region, the **Red Sea Mountains** and the fringing plateaus are all dissected by drainage nets, which drain either toward the **Red Sea** in the east or toward the **River Nile** in the west. The heights of some mountainous peaks in this region may reach more than 2000 m a.s.l, whereas those of the plateaus vary greatly between more than 1000 and several hundreds of meters above sea level. Very few localities at the southern end of the **Gulf of Suez** are a few meters below sea level.

The Red Sea Mountains range extends southward from **Gabal Um Tenasib** (latitude 28° 30′ N) parallel to the coastline of the Red Sea up to and beyond the Egyptian borders within the Sudan. The mountains do not in fact form a continuous range, but are rather disconnected blocks separated by basins and deep wadis. Along this range, about 30 peaks rise more than 1000 m a.s.l, such as Gabal Qattar (1963 m), Gabal Abu Abid (1900 m), **Gabal Hamata** (1977 m), Gabal Shendib (1911 m), and **Gabal Shayeb Al-Banat** (2187 m). These mountains are formed of igneous and metamorphic rocks, with a thin sedimentary cover along the eastern flanks. Due to the effect of tectonics, the eastern slopes of the mountains are steeper than the western flanks,

leaving a narrow coastal plain along most of the Red Sea coast.

To the north and west of the mountains, vast plateaus extend to the Nile Valley. The southern sandstone plateau is called **El-Ababdah Plateau**, extending northward from the Egyptian-Sudanese borders to the Qena Bend of the Nile Valley. This plateau is highly dissected by wadis that reach the Nile Valley, of which wadis **El-Allaqi**, **Shait**, and **Kharit** are the longest. This plateau is characterized by the presence of some large basins, such as the one lying to the east of Kom Ombo city in the Nile Valley. This basin is filled with fluvial sediments originated from the two wadis of Kharit and Shait draining from the Red Sea Mountains. These materials are covered by the silt of the Nile and that is why the surface of the basin has the appearance of a vast plain. It is called **Kom Ombo Plain**. To the east of this plain, another basin is developed and is called **Atmur Noqra**. The northern extensive limestone tablelands carry the names (from north to south) of **Gabal Ataqa**, **El-Galalah El-Bahariyah**, **El-Galalah El-Qibliyah**, and **El-Maaza**. Only the two Galalahs attain heights that reach more than 1000 m a.s.l. These two Galalahs are separated by the very wide (30 km) wadi named Wadi Araba that represents a reversed topography feature, since it is originally a structural swell. In addition to the wadis dissecting the plateaus, inliers, outliers, and gravel sheets characterize the surface of the plateaus. Due to the effect of tectonics, the northern margins of the Eastern Desert are divided into several separate hills, which rise several hundreds of meters above sea level. Examples of these hills are Gabal Uweibed, Gabal El-Nasuri, and Gabal El-Anqabia. To the north of these hills, ancient fluvial deposits cover the plains extending to the east of the Nile Delta. These plains decrease in height from about 200 m asl in the south to a few meters above sea level in the north.

Along the coasts of the Gulf of Suez and the Red Sea, a narrow coastal plain developed between the coastline and the foot slopes of the mountains. The plain is covered with fluvial sediments that were deposited during the past pluvial periods. Ancient coral reefs, raised beaches, and marine terraces are characteristic features in this plain. The width of the plain varies from one place to another, where it widens in the area of **Aish El-Mallaha** in the north and in the area of **Halayib**, and **Shalatin** in the extreme south. The coastline of this plain is generally straight due to the tectonic origin of the Red Sea. Fringing coral reefs developed along most of the coastline of the Gulf of Suez and the Red Sea.

The Eastern Desert is highly dissected by drainage networks, which can be divided into two opposite systems. The first is the Red Sea drainage system, with short wadis and small basins in general, whereas the second may be called the Nile-Mediterranean drainage system, with relatively long wadis and large basins. Examples of the Red Sea wadis are Araba, Abu Had, El-Mallaha, Safaga, Gasus, El-Hammamat, El-Gimal, Hodain, and Kraf. Examples of the wadis of the second system are Sannur, Tarfa, Assyuti, Qena, Shait, Kharit, and Allaqi. **Wadi Qena** is distinguished from other wadis in that its main course runs for about 200 km in a north–south direction, which is almost opposite to that of the Nile Valley. **Wadi El-Allaqi** with its extension in the Sudan is by far the largest in the Eastern Desert.

1.5 The Sinai Peninsula

Though considered a subregion of the Eastern Desert, the **Sinai Peninsula** with a distinct triangular shape possesses its own characteristics. It is bound from the north by the Mediterranean Sea, from the west by the Gulf and Isthmus of Suez, and from the east by the **Gulf of Aqaba** and the Palestinian-Israeli boundary. Sinai covers about 6% (61,000 km^2) of the total area of Egypt. Its coasts extend for about 700 km, a characteristic which makes Sinai less continental compared to other regions of Egypt. In Sinai, nearly all the geologic formations, structures, and landforms of Egypt are represented. Moreover, regional climatic variations are quite similar to those of Egypt. Due to these characteristics and its distinctive location in Egypt, Hamdan (1980) called Sinai "Egypt Minor."

The southern part of Sinai is the mountainous Sinai, whereas the central part is a tableland region. The northern part is divided into two subdivisions: isolated domal hills and mountains in the southern subdivision, whereas the northern part is mainly covered by sand dunes. Southern Sinai consists of high, complex, and rugged igneous and metamorphic mountains. Most of these mountains rise more than 1000 m asl. However, several peaks rise above 2000 m asl, of which **Mount St. Catherine** (2641 m a.s.l) is the highest not only in Sinai, but also nationwide (Fig. 1.1). Other conspicuous peaks are Gabal Um Shomar (2586 m), **Gabal Mousa** (2285 m), and Gabal Serbal (2070 m). The mountains are dissected by incised drainage lines which drain either into the Gulf of Aqaba in the east or the Gulf of Suez in the west. Examples of wadis draining into the Gulf of Aqaba are (from north to south) Watir, Dahab, and Kid, whereas wadis Baabaa, Sudr, and Feiran are examples of those draining into the Gulf of Suez. Due to this dissection and the effect of lithological variations, the peaks have the appearance of a jigsaw (Fig. 1.7). However, some of the high areas are bevelled and appear as high plains. These are the Haute Surfaces of Awad (1951). They are locally known as farsh, which means flat surface, such as Farsh Zebir, Farsh Itla, and Farsh El-Qasab. Because they are sites for fluvial deposition, intermountain basins lying between peaks have the appearance of small isolated depositional plains.

The eastern slopes of the **Sinai Mountains** directly overlook the waters of the Gulf of Aqaba, except for the