Arabian Deserts
Nature, Origin, and Evolution
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by

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Preface

More than 50 years ago I went to Arabia as a young geologist and was fascinated by its desert landforms and its hospitable people. In retrospect, I have spent more than half my life there, first in exploration for oil, and a greater part in geological education. As I have travelled widely in Arab countries, it seemed only appropriate to put together my thoughts and observations on the varied desert landforms of Arabia that have so impressed me.

When I first arrived in Arabia in 1954, it was sparsely populated and many tribal people had never seen a motor vehicle before. Our efforts then resulted in the discovery of the first oilfield in Oman, at Marmul in 1955. Now, oil wealth has transformed Arabia, so that many of its people live in air conditioned housing and, even opulence, quite different from their forebears. Nevertheless, the great majority of Arabia’s 120 million inhabitants still live in desert conditions, and only some areas like Lebanon, western Syria, and parts of the Yemen highlands have milder climates.

The great sand dune deserts of Arabia are amongst the largest in the world and Ar Rub’ al Khali, or the Empty Quarter, is the world’s largest continuous sand desert. Where else can one find great linear dunes, which the Arabs call ‘uruq or veins, running for hundreds of kilometres, indeed, up to 500 km long for a few individual ‘uruq? Many other giant transverse sand dunes also extend for over 100 km and are up to 230 m high. Here, I have attempted to record, classify, and explain the great many different forms of sand dunes encountered in Arabia covering an area the size of France and Britain combined. My observations on the ‘Evolution of the Rub’ al Khali Desert’ were first published in 1989.

These sand deserts are far from the only deserts in Arabia, and vast areas of western Saudi Arabia, Jordan, Syria, and Yemen are covered by the rugged terrain of lava fields, or harrah, some of quite recent origin. Their black surfaces absorb maximum heat, unlike the light reflective sand deserts, and form a particularly inhospitable type of rocky desert. Widespread gravel deserts known as hamadah also cover large parts of northern Arabia, including much of the Syrian Desert.

Along the coasts of Arabia, extensive saline flats are so well developed, that they have been adopted by geologists as the type for sabkhab, whose gypsiferous deposits develop into anhydrite, an important cap rock in oilfields worldwide. These sabkhab areas not only form distinctive saline deserts along the coasts of
the southern Persian Gulf and eastern Red Sea, but are also found inland as widespread continental sabkha where saline groundwater is near the surface.

In the hot arid environment of most of Arabia with evaporation exceeding rainfall by more than one hundred times, drainage is almost all in the form of dry watercourses known as wadis, or more correctly widyans. Their flow is so infrequent as to lead to the formation of many enclosed drainage basins often with claypan deposits, known locally as qa’, or khabra’. These frequently cover large areas and are another type of desert.

Even the plateaux and mountains of Arabia are generally so dry that they constitute two further types of deserts with difficult terrain and their own characteristics. The large Hadramawt Plateau of southern Yemen and Al Hajar, or Oman Mountains, of northern Oman are examples of these desert types.

In this book, I have attempted to cover all of Arabia and all the various types of deserts that are found there. Examples are given for each type and these are mostly illustrated by photos taken in the course of my work and travels throughout Arabia from 1954 onwards. In some cases colleagues have kindly provided additional photos. In other cases I have relied upon satellite imagery, especially NASA’s near-infrared Landsat 7, and Aster images made available by the U. S. Geological Survey, as well as occasional high resolution scenes released by SPOT Image. The seamless Landsat 7 2000 series imagery from NASA’s John C. Stennis Space Center has proved especially useful.

I have lived and worked in Oman, Saudi Arabia, and Lebanon, in addition to field work in Syria, Jordan, and Kuwait, as well as travels in Iraq, Yemen, and in Palestine before 1967. These experiences have given me a fairly comprehensive coverage of the deserts of Arabia. Some of my observations and interpretations are already published in some 24 publications on various aspects of the geology, geomorphology and hydrogeology of Arabia, as well as in 20 reports, 6 of which are coauthored.

Although I have taken considerable care with details of places and facts, some readers may find other place names more suitable. Here, I have followed the instructions of the Permanent Committee for Geographic Names with regard to Arabic place names. So many Arabic terms have been used or misused in the geological literature that I have felt it necessary to append a Glossary of Arabic Terms for Arabian deserts, to which the reader may refer.

Early European travellers too found a certain fascination with the deserts of Arabia, and it is interesting to see that one of the few reasonable published accounts of the 57,000 km² An Nafud Desert and much of northern Saudi Arabia is by Lady Anne Blunt in 1881. A good description of the terrain and lava fields of northern Arabia is also given by Doughty (1888). Classic travel accounts of Ar Rub’al Khali Desert are given in the books of Thomas (1932), Philby (1933), and Thesiger (1959).

Apart from major map sources, I have gone carefully through a multitude of available publications on or related to, the deserts of Arabia and have tried to incorporate their main findings.
Since the Arabian American Oil Company (now the Saudi Arabian Oil Company) became established in 1948, numerous geological surveys of Saudi Arabia took place mostly published as a series of detailed maps by the U. S. Geological Survey beginning in 1963. The author prepared the first geological map of southern Oman in 1956. For the Oman Mountains of northern Oman a team of Shell Oil geologists prepared the first published map in 1974 (Glennie et al., 1974). Details for the Syrian Arab Republic by a team of Russian geologists are integrated in the work of Ponikarov et al., (1967). The basic references for Jordan are the 1968 ‘Geologische Karte von Jordanien’ by the Bundesamt für Bodenforschung and Bender’s ‘Geologie von Jordanien’ (1968). For much of Yemen one has to still rely on the work of von Wissmann et al., (1942), although Beydoun’s geological accounts of the East Aden Protectorate, now southern Yemen (1964, 1966) are still relevant. For Iraq, a comprehensive map in 2 sheets published by the Directorate General of Geological Survey and Mineral Investigation in 1986 provides coverage at a scale 1: 1 million.

All the above works are essentially geological and pay little attention to the nature of desert landforms, their origin and development. This book considers the many aspects of Arabian deserts not only as developing landforms, but also in relation to climate, palaeoclimate, ecology, and sedimentology. I have attempted to trace the history of the development of the deserts of Arabia and to show the ways in which these have been dated, as well as to indicate further methods by which they may be dated and studied.
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Fig.7.17. Late Pleistocene lake bed deposits between dunes in the south–western Rub’ al Khali. (Photo credit H. A. McClure “Saudi Aramco World” 1989/PADIA).

Fig.7.18. Hippopotamus teeth from the Late Pleistocene lake beds of the south–western Rub’ al Khali. (Photo credit M. S. Shabeeb, “Saudi Aramco World” 1989/PADIA).

Fig.7.19. Dune type distribution in the Rub’ al Khali Desert and surroundings.

Fig.7.20. Geological setting of An Nafud Desert in northern Saudi Arabia annotated with standard geological symbols. The detailed drainage is added to show how An Nafud has no drainage. (Constructed from data in Hearn et al 2003).

Fig.7.21. Broad linear dunes of the central Nafud bearing giant crescentic hollows and slip faces facing east. Photo looking north–west. (After Holm, reproduced by permission of “Science”, No. 3437, Fig. 3, p. 1373, photo credit Saudi Arabian Oil Company).

Fig.7.22. Large linear dunes, or ‘uruq 40–60 m high of the north–central An Nafud with small linear dunes on their surfaces. Numerous crescentic slip faces representing lines of barchans lie mainly in the interdunes and only occasionally on the ‘uruq. Inverting the image makes the pattern clearer. Image width is 12 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).
Fig. 7.23. View of a broad linear dune in the southern An Nafud showing well-established vegetation on the nearly stabilized crescentic slip face. (Photo reproduced by kind permission of F. Oberlaender).

Fig. 7.24. Star dunes with 3–5 arms in the eastern An Nafud Desert, northern Saudi Arabia. Note their linear arrangement. Farther west, they merge into broad ‘uruq, or giant linear dunes. The darker bands are salty sabkha areas of shuquq, or interdunes. Image width is 5 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 7.25. Barchanoid dune ridges, here about 100 m high on the central western edge of An Nafud. Stoss slopes are relatively broad with frequent irregular seif dunes. The bare area on the west (left) consists of Palaeozoic beds swept clear of sand by westerly winds. Image width is 12 km and is clearer viewed inverted. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 7.26. Distribution of different dune types in An Nafud Desert.

Fig. 7.27. Lake beds of Early Holocene age, 7.5 km E. of Jubbah, southern An Nafud, northern Saudi Arabia seen on the right behind fence. Lower Palaeozoic sandstones of the Saq and Tabuk formations of Jabal Umm Silman in background and sand dune in foreground and left. (Photo credit C. Newman).

Fig. 7.28. A composite of two images showing Ad Dahna Desert extending in a great outer arc around the escarpments of the Interior Homocline from upper left corner where it joins An Nafud to near lower right edge, where it joins the Rub’ al Khali. The Arabian Shield is on the west (left) and the Nafud ad Dahi can be seen extending northward from the middle of the lower edge. Image width is 645 km. (NASA Landsat 7 images 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 7.29. Closely spaced linear sand dunes in the narrower northern Ad Dahna. Image width is 20 km. (Image ISS005-E-9293_1000; Courtesy of NASA Earth Observatory).

Fig. 7.30. Star dunes on ‘uruq of the north–eastern Ad Dahna in the Hawmat an Niqan area, NE Saudi Arabia, as seen in the lower four ‘uruq. Image width is 6 km. Individual star dunes are over 100 m high and up to 1.5 km in diameter. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 7.31. Large, chevron-shaped dune complexes of the southern Al Jafurah Desert composed of barchanoid ridges, and barchans on their leeward sides. Image width is 15 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 7.32. Barchan dunefield on Sabkhat ad Dabbiyah, west of Qatif. Image width is 4 km. Small nested parabolic dunes occur on the south–east (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).
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<td>Wind rose for Ad Dhahran, typical for the Jafurah Desert. The red line represents wind direction (i.e., the direction winds come from) in percent. (From ‘Saudi Arabian Wind Energy Atlas, Al-Ansari et al., 1986).</td>
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<td>Ramlat as Sab’atayn – a mosaic of Landsat 7 images. The sinuous linear dunes or ‘urruq are quite different from those of the Rub’ al Khali. Image width is 260 km. (Source NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).</td>
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<td>7.35a</td>
<td>Ramlat as Sab’atayn eastern part, showing large curved linear dunes, or ‘urruq from lower centre to top right, with numerous small barchan dunes, with south-east-facing slip faces on their surfaces, and especially occurring in interdunes. An old watercourse appears near the mid line of the image and has even cut the dunes locally. Lower Tertiary limestones of the Hadramawt are dark on the lower right. Scattered outcrops of the Cretaceous Tawilah Group occur in the lower mid right. The ancient city of Shabwah lies in the white area in the lower right corner. Image width is 50 km. (U.S. Geological Survey Aster VNIR image ID: AST_LIB.003.2009436874).</td>
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<td>An enlarged view of the distinctive pattern of barchan-like hollows, with east to south-east facing slip faces, which appear rarely on large, linear dunes of the eastern Ramlat as Sab’atayn, but are quite concentrated in interdunes, or shuquq. The dunes are narrower, 30 m high, about a third the width of interdunes, and bear a pattern of short linear seif dunes. Width of the image is 12 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).</td>
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<td>A satellite image of the Ramlat Al Wahibah (Wahiba Sands) consisting mainly of large linear dunes, or ‘urruq, except the narrow southern part, which consists of narrower N–S trending dunes and some sand sheet. Width of the image is 100 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).</td>
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Fig. 7.40. ‘Uruq of the north–western Ramlat Al Wahiba, or Wahiba Sands. Note the numerous oblique seif dunes on the surfaces of ‘uruq and the relatively narrow interdunes. Width of the image is 6 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 7.41. ‘Uruq of the north–eastern Ramlat Al Wahiba showing a pattern of broad, asymmetrical, north-facing mounds on their surfaces. These mounds contain a cross pattern of small sigmoidal dunes. Interdunes are narrow and often contain long seif dunes. Image width is 7.7 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 7.42. View of dunes in the north–eastern Ramlat Al Wahiba showing the hummocky nature of many ‘uruq. (Photo reproduced by kind permission of I. Barker).

Chapter 8. Lesser dunefields of Arabia.

Fig. 8.1. Nafud ath Thuwayrat seen from lower right to mid top. The Nafud as Sirr is on the lower mid image extending to Wadi ar Rimah. Nafud ash Shuqayyiqah is seen near the lower left corner and Nafud al Ghamis is just above it, including Nafud Buraydah, while Nafud at Tarifiyah is NW of Nadud as Sirr. Width of image is 133 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 8.2. Nafud ath Thuwayrat on its north–western edge with dome dunes and barchan ridges. Image width is 45 km. (U. S. Geological Survey Aster VNIR image ID: AST_LIB.003.2019083427).

Fig. 8.3. Dome dunes of Nafud as Sirr with short peripheral radiating ridges. These dunes are mostly over 1 km in diameter and up to 150 m high, but mostly 50 m high. Some seif dunes trend NNE–SSW. The black circles are centre-pivot irrigation plots. Image width is 30 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 8.4. Dome dunes on the southern end of Nafud Qunayfidah near the main road 150 km west of Ar Riyadh. These dunes have an average diameter of 1 km. Image width is 30 km. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 8.5. Linear dunes of Nafud al Ghamis (middle to lower left), including Nafud al Buraydah (lower centre), and Nafud at Tarafiyyah (top right). The city of Buraydah is seen to the left of centre. Image width is 30 km centred at lat. 26.18° N; long. 43.47° E. (NASA Landsat 7 image 2000 series, courtesy of nasa.gov/mrsid/mrsid.pl).

Fig. 8.6. Large linear dunes or ‘uruq of the Nafud al Mazhur on the left with minor small linear seif dunes on their surfaces. Giant dome dunes of the Nafud ath Thuwayrat are seen on the right.