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Mehran Maghsoudi

Desert Landscapes and Landforms of Iran

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ISSN 2366-8865 ISSN 2366-8873 (electronic)
Geography of the Physical Environment
ISBN 978-3-030-58911-0 ISBN 978-3-030-58912-7 (eBook)
https://doi.org/10.1007/978-3-030-58912-7

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Acknowledgements

I am grateful to Farajollah Mahmoudi, Mojtaba Yamani, Seyed Mohammad Zamanzadeh, and faculty members of the University of Tehran for scientific advice at all stages in the preparation of this book. Also, I am thankful to the University of Tehran and to the Iranian Cultural Heritage and Tourism Organization for allowing me to go to the interior part of the Iranian Desert, especially Lut Desert world heritage. I am also grateful to Amir Moradi, Anvar Moradi, Mohammad Ali Nezammahalleh, Afsaneh Ehdaei and Omid Rahimi for preparation of maps and editing of the text. I thank Vhaid Mohammadnezhad for courtesy of some maps about alluvial fan evolution in Iran. I am also thankful to Hojat Kamali, Alireza Amrikazemi, Sahar Maleki, Mohammad Gaeini, Ebrahim Nikkhoo, Mehdi Yaghoubi, Nourollah Nikpour, Younes Sharyatmadari, Reza Safaeirad, Daryoush Mehrshahi, Mohammad Reza Taherdin, Esmaeil Allahpour, Reza Khlili Varzaneh, and Matin Setayesh for assistance in providing some photos of Iran. I also thank Springer, particularly Ambrose Berkumans, Michael Leuchner, Doris Bleier, and Robert Doe for their support to prepare this book. Finally, I thank Moein Afzali, Seyed Ahmad Rounaghi, and Hamed Shadravan for accompanying me in field survey in Lut Desert.

Contents

Introduction to Landscapes and Landforms of Iran

1

Abstract

Iran as a country located in the southwest Asia is mainly covered by arid, semiarid, and hyper-arid climatic conditions. The country has high geological, climatologic, biologic, and cultural diversities. For example, though it is located in the hot spot of the world in the Lut Desert, several parts of highlands in Alborz and Zagros Mountains experience below zero temperature in the summer. Sedimentary-structural units and climate conditions configured main landforms and landscapes of Iran. Two mountainous areas of Alborz and Zagros are formed by the main topographic components of the country. These mountains have inevitable effects on climate, hydrology, and even history and cultural aspects. The six first-order and thirty second-order watersheds with different types of rivers and aquifers supply surface and ground water for any human activities. Paleoenvironmental studies show the effects of complicated relationship between human activities and environmental functions during the history.

Keywords

Administrative divisions of Iran · Geology of Iran · Structural unit of Iran · Climate of Iran · Morphoclimatic regions of Iran · Hydrology of Iran · Human settlements · Alborz Mountains · Zagros Mountains

1.1 Introduction

The landscapes and landforms of Iran are highly influenced by climate (morphoclimatic region), geology (structure and stratigraphy), and also topography. Combinations of these factors are generating a variety of landforms and landscapes around and inside Iran. In fact, endogenic and exogenic processes have formed different landscapes and landforms of Iran. More than 53.3% of Iran is between 1000 and 2000 m above sea level and 15.7% is over 2000 m (National Cartographic Center of Iran 2004) (Table 1.1). Several mountainous areas are developed in all Iran (Fig. 1.5). Zagros Mountains are extended from northwest part of Iran, beyond the border with Turkey and Iraq, to southeast and continued to the Persian Gulf. In this area, in simple folded structures, the synclines coincide with vast plains in the southern part and the anticlines coincide with mountains (Fig. 1.1). This kind of landform evolution is similar to that in Jura Mountains. In southwest Iran, Khuzestan Coastal Plain is located at the southeastern fringe of Zagros Mountains. In Northern part of Iran, Alborz Mountains is stretched from west to east in southern coast of the Caspian Sea. The Alborz Mountain Range separates the northern forest environment of Iran from the southern arid lands of the country. The highest summit of Iran, Damavand, as a volcanic peak is located in central part of the Alborz Mountain Range

M. Maghsoudi, *Desert Landscapes and Landforms of Iran*, Geography of the Physical Environment,
https://doi.org/10.1007/978-3-030-58912-7_1

Table 1.1 Area and percent of different levels of elevation in Iran

Elevation (m)	Area (km^2)	Area (%)
Over 2000	260,000	15.7
1000–2000	879,000	53.3
500–1000	154,000	9.3
0–500	332,000	20
Interior lakes	14,000	0.9
Lower than zero	11,000	0.7
Total	1,650,000	100

National Cartographic Center of Iran (2004)

Fig. 1.1 Anticlinal of Zagros Mountains near the Persian Gulf

(Fig. 1.2). The Damavand, an inactive volcano with 5671 m high (Allenbach 1966), is the highest mountain in the Middle East and Europe.

The only active mountainous glacier in Iran is also located in central part of the Alborz in Alam Kuh, about 4850 m high, in the west part of Damavand peak. There are a narrow coastal plain like a strip between Caspian Sea and Alborz Mountains. Several small rivers are flowing from mountainous slopes in south to north (Alborz Mountains to Caspian Sea). Only Sefid Rud River cuts the Alborz Mountains and flows from the west part of Iran to the northern coastal region. In the east part of the Caspian Sea, the coastal plain is gradually connected to Turkmenistan desert area. In this area, there are some active mud volcanos emitting mud flows outside. In south part of Iran, we can observe different

Fig. 1.2 Damavand Peak in Alborz Mountain range (view from the southwest)

conditions. Several different landscapes can be seen in the coast of Persian Gulf and Oman Sea. In the east coast of Oman Sea, between the Minab City and ports of Beris several mud volcanos and beautiful badlands can be observed in the vicinity of coastal landforms. Several coastal sand dunes and ergs are also located between Hormuz strait and Chabahar City, a hub far southeast Iran. There are also some estuaries and lagoons in this area. From Hormuz Strait to the west around the coastal strip, there are some landforms including some dunefields, salt domes, very long anticlinal, and several estuaries such as Khor-E Mousa and other arid and semiarid landscapes.

In the northwest of Iran, there are two inactive volcanic peaks. Sabalan and Sahand Volcanos are located in the mountainous area in northwest Iran. In the west part of Sahand Summit, Lake Urmia is located at more than 1275 m above mean sea level (MSL) which in recent years is increasingly drying as a result of drought and mismanagement of water resources (Sharifi et al. 2018). Generally, aridity condition of Iran is increased from north to the south and from west to the east (Zolfaghari et al. 2016). Also arid landforms and landscapes are increased from north to south and from west to east. In the south of Alborz Mountanis, there are several playas such as Great Kavir (Dasht-e Kavir), Qom Lake, and Haj Ali Gholi playa (Damghan) and also several ergs and dunefields such as Rig-e Kharturan, Rig-e Jen, Band-e Rig, and Rig-e Sargardan. In fact, there are more than 20 big ergs and dunefields in a region among the southern Alborz Mountains in the north; Zagros Mountains in the west; coastal areas in the south; and boundaries between Iran, Afghanistan, and Pakistan in the east (Mahmoudi 2002). Several small dunefields and more than 60 playas also occurred within this area (Krinsley 1970). Also several coastal sand dunes and ergs are also located between Hormuz strait and Chabahar City, a potential tourism hub for southeast Iran. Lut Desert as a world heritage with spectacular desert landforms in the southeast Iran is one of the best examples of desert

landforms in Iran with huge diversity. In different parts of Iran, extinct and dormant volcanic areas can be seen mainly in the eastern part of Iran, where there are some volcano peaks (Taftan, Khezre Zendeh, and Masinan). Some small volcanos can also be seen in Takab area in northwest of Iran. In the western part of Lut Desert (near Lut Desert world heritage nominated properties), we can see some small volcano cones and lavas which are coincident with Nayband fault (from north to south direction). Many young lavas and volcano vents can also be seen in the south of Lut Desert. Volcanic belt called Urmia-Dokhtar is extended from northwest to southeast as another volcanic region of Iran. Karstic landscape and landforms are one group of the important landscape and landforms in Iran. In the middle part of Iran, karstic landforms show the climate changes in this region. There are a plenty of karstic landforms in Iran mainly in Zagros Mountain Range, Koppeh (Kopet) Dagh (northeast of Iran), and many other mountainous areas of Iran. There are also many surface karstic landscapes including canyons (Fig. 1.3), sinkholes, polje, travertine spring rim, karstic pavement, and all kinds of Karen. Some of the karstic features are also concentrated mainly in karstic caves such as Alisadr, Katale Khor, and Chal Nakhjir.

In Persian Gulf, there are some Iranian islands with special geologic and geomorphologic landscapes (Fig. 1.4). The greatest island in the Persian Gulf is Qeshm Island formed by four anticlines and salt domes. Some of the islands are formed by ancient coral reef, some formed by salt domes, and others by terminal parts of Zagros Mountains extended to this area (Fig. 1.5).

Fig. 1.3 Shirez Valley (canyon) located at the folded Zagros area

Fig. 1.4 Pot hole in Qeshm Island (photograph by Ebrahim Nikkhoo)

1.2 Location of Iran

Geopolitical position of Iran, with 1,648,195 km^2 in area, is located in the Middle East, between Persian Gulf in the south and Caspian Sea in the north (Fig. 1.6). The neighboring countries of Iran are Pakistan and Afghanistan in the east; Azerbaijan, Armenia, and Turkey in the northwest; Iraq in the west; and Turkmenistan in the northeast. Southern border of Iran, about 25° N, is very close to Tropic of Cancer and it is continued to latitude about 40° N. The boundary of Iran is started in Longitude 44° E and continued to about Longitude 63° E. In the south, the coastal area along the Persian Gulf is continued from Arvandrud River to Hormuz strait and Bandar Abbas and then to Chabahar City and Guater Bay. The length of the coastal area in the south Iran is

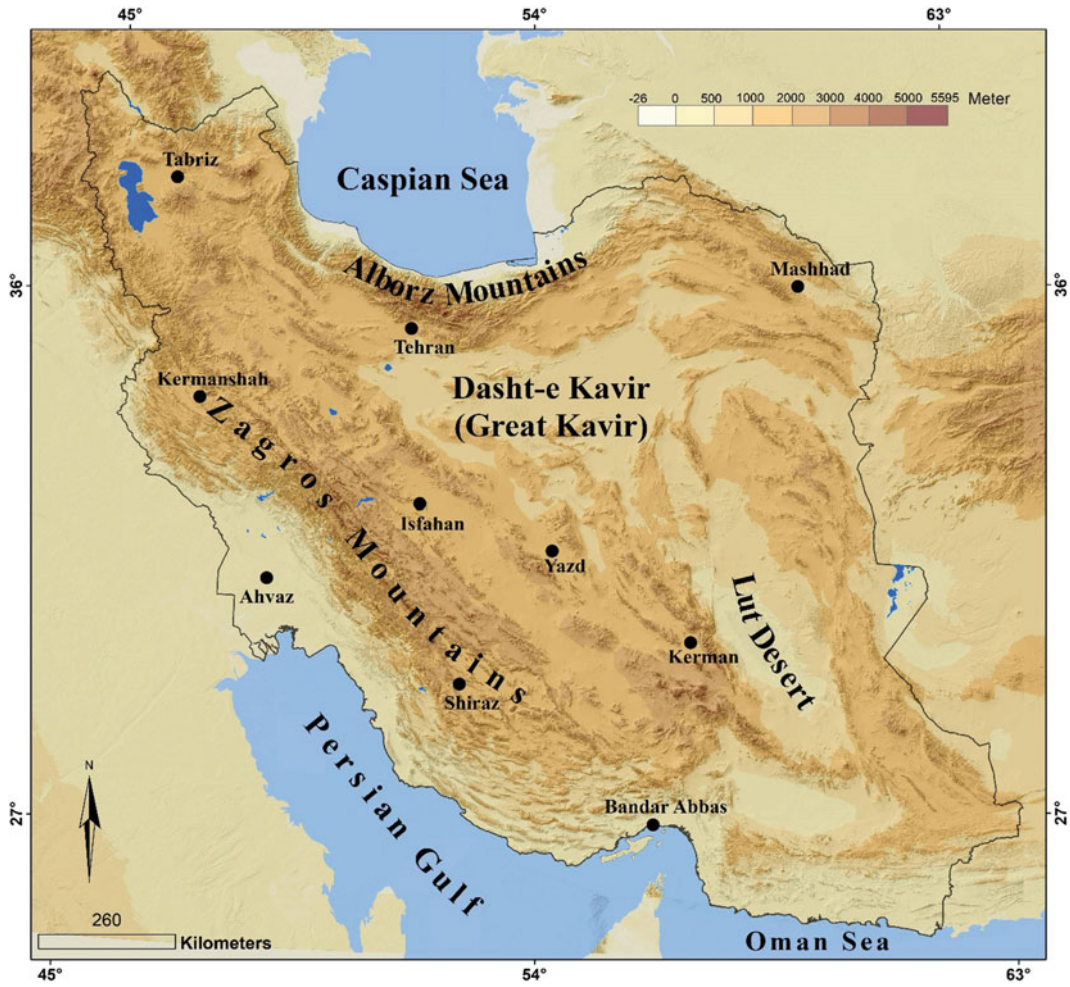

Fig. 1.5 Physical terrain map of Iran

about 2106 km. The neighboring countries of Iran around the Persian Gulf are UAE, Saudi Arabia, Kuwait, Iraq, Bahrain, Qatar, and Oman. In the north, Caspian Sea is continued from the boundary between Iran and Azerbaijan and continued to the east where it is connected to the boundary between Iran and Turkmenistan. Length of coastal shoreline of Caspian Sea inside Iran is about 524 km (Statistical Center of Iran 2016a, b). In Caspian Sea, Iran has four neighbors including Russia, Kazakhstan, Turkmenistan, and Azerbaijan.

1.2.1 Administrative Divisions of Iran

Iran has different levels of administrative division such as province (Ostan), county (Shahrestan), district (Bakhsh), and rural district (Dehestan). On the other hand, there are several cities located in the provinces and its subdivisions. Based on the records in 2016 (Statistical center of Iran 2016a, b), there were 31 provinces, 429 counties, 1057 districts, 2589 rural districts, and 1242 city in Iran (Statistical center of Iran 2016a, b). The provinces have different areas;

Fig. 1.6 Location of Iran in Middle East

generally those located at the desert area are bigger than others. The biggest provinces in desert areas of Iran are Kerman, Sistano Baluchestan, Khorasan-e Jonubi, Isfahan, Semnan, and Yazd (Fig. 1.7).

1.3 Geology of Iran

Geological characteristics of Iran are widely dependent upon tectonic and structural nature (Khosrotehrani and Darvishzadeh 1984; Berberian 2014; Ghorbani 2014). The geological evolution of Iran is mainly related to sedimentary basins, tectonic phases, and magmatism as intrusive and extrusive rocks. The geological structure of Iran Plateau is configured between Arabian and Eurasia plates. It is believed that geologic structure of Iran is located in the middle part of Alpine–Himalayan orogenic belt. This belt starts from the west part of Europe and stretched through Turkey, Iran, Afghanistan, and then ends in Tibet (Aghanabati 2004). Sometimes, it is believed that the Alpine–Himalayan orogenic belt is extended from Atlantic Ocean to Western Pacific (Ghorbani 2013).

Most studies about geological evolution of the country are explaining great Tethys as an ocean between two continents of Gondwana and Eurasia (Darvishzadeh and Mohammadi 1995; Darvishzadeh 1991; Aghanabati 2004). In fact, position of Zagros and Alborz Mountains is

Fig. 1.7 Administration division map of Iran (map based on data from Statistical Center of Iran 2016a, b)

related to the branches of this ocean. However, some scientists believe that such statements are not supported by appropriate scientific evidence.

Studies about geology of Iran return back to 1850 by some scientists such as Viquesncl (1850), Blanford (1873), Tietze (1875), Stahl (1897), de Morgan (1905), Eeni (1931), Baier (1938), Riviere (1934), Clapps (1940), Furon (1941), Bobek (1934, 1938), Schroeder (1944), and many others (in Khosrotehrani 1988). In 1959, the first geological map of the country was published by Iranian Oil Company at scale of 1:2,500,000 and then the geological map of Iran at scale of 1:1,000,000 was published in 1977. In 1959, Geological Survey of Iran was established and extensive studies were conducted and many geological maps at scales of 1:250,000 and 1:100,000 were produced for different parts of the country. Iranian Oil Company and Geological Survey & Mineral Explorations Organization published some maps including Tectonic map of Iran (Stöcklin and Nabavi 1973) and seismotectonic map (Berberian 1976).

1.3.1 Geological and Structural Unit of Iran

Some geologists proposed lithologic and tectonic division for the geological structure of Iran.

Stöcklin (1968) was the first geologist that suggested a map for structural-sedimentary unit of Iran based on tectonic, structural, and sedimentary structure. After Stöcklin and Nabavi (1973), Eftekharnejad (1980), Berberian and King (1981), and Aghanabati (2004) introduced new structural and sedimentary structural and sedimentary zonations for the country.

Based on some studies (Khosrotehrani and Darvishzadeh 1984), the main factors for zoning of sedimentary-structure division are:

1. Age of different units or zones;
2. Sedimentary basins and related facies;
3. General trends with different neighboring units;
4. Magmatism and metamorphic activities; and
5. Orogenic activities, tectonic, and structural styles in different units.

According to abovementioned factors, Iran geological environment is divided into the following units (Fig. 1.8):

1. Zagros sedimentary-structural unit
   - Folded Zagros
   - Zagros Thrust or high Zagros, and
   - Khuzestan Plain
2. Sanandaj-Sirjan sedimentary-structural unit.
3. Central Iran
4. Eastern and southeast Iran
   - Nehbandan-Khash or flysch unit,
   - Lut block
   - Makran (Mokaran).
5. Alborz
   - Eastern Alborz and Koppeh Dagh,
   - Central Alborz, and
   - Western Alborz and Azerbaijan.

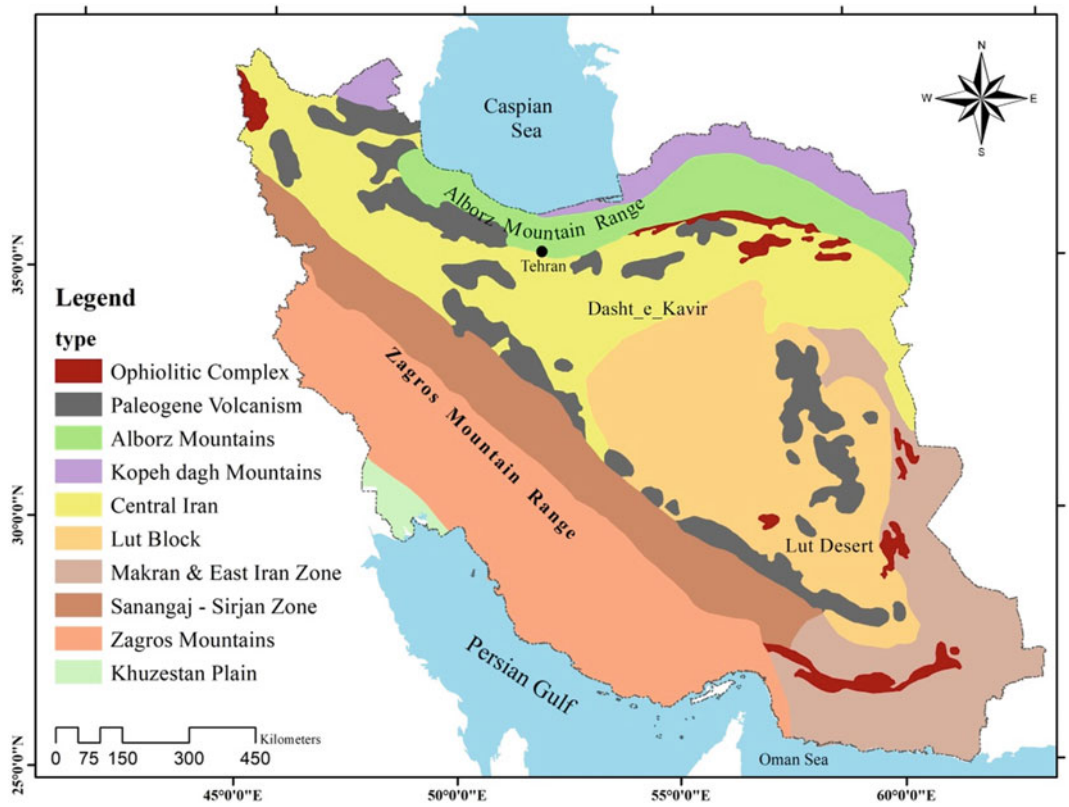

Fig. 1.8 Sedimentary-structural units of Iran (after Aghanabati 2004)

1.3.1.1 Zagros Sedimentary-Structural Unit

Zagros Mountain Range is configured by classic folding in tertiary period. In fact, Zagros Mountain Range with northwest–southeast orientation is the biggest sedimentary-structural unit of Iran. The "Zagros is a more than 1500-km-long NW–SE trending mountain belt of extensive crustal deformation and intense seismic activity with pronounced topography" (Berberian 2014, p. 152). In the eastern part of the geological structure of Iran, near Hormuz strait, the boundary between Zagros and Mokaran is distinguished by Minab Fault. This unit is connected to Sanandaj-Sirjan sedimentary-structural unit in the north and also connected to Mesopotamia in the west.

1.3.1.2 Folded Zagros

The folding section of the Zagros, like other sections with a northwest–southeast trend, is approximately between 150 and 250 km wide. This folded section is parallel to the Zagros Thrust Fault (ZTF or High Zagros). The NW–SE orientation changes into a west–east trend in northern areas of Persian Gulf (Fig. 1.9). The Zagros Thrust is separated from Central Iran unit by a strip-like metamorphic unit, Sanandaj-Sirjan. From infracamberian to middle Triassic, the Zagros has experienced almost the same situation as Central Iran and Alborz Mountain Range (Aghanabati 2004; Darvishzadeh and Mohammadi 1995; Khosrotehrani and Darvishzadeh 1984). Following Triassic Period, this part of country was separated from other parts as subsidence basin and geosynclinals (formation of Tethys). Thousand meters of sediment were deposited during this period. These deposits are mainly composed of marl, sandstone, shale, and carbonate. At the end of Miocene, some of the abovementioned sediments are folded and emitted out of ocean (Darvishzadeh and Mohammadi 1995).

In the next stage, due to the collision between Arabian and the Eurasian plates the orogenic phases were started.

1.3.1.3 Zagros Thrust or High Zagros

The highest peaks of Zagros Mountains were formed by the ZTF activity. Although the Zagros

Fig. 1.9 Google Earth image of folded Zagros

Thrust unit is intensively fractured and faulted, its orientation is from northwest to southeast parallel to the folded Zagros, from 10 to 60 km wide (Jadari Eyvazi 1995). This zone has been called "crashed unit" (Mahmoudi 1993). This unit is extended from Bandar Abas in south to the Marivan in west Iran and then continued along with folded Zagros through Turkey.

1.3.1.4 Khuzestan Plain

Khuzestan Plain covered with Quaternary sediments is part of Arabian Plateau and named as unfolded Zagros by Mahmoudi (1993). These Quaternary deposits are developed over sequences of Paleozoic to tertiary rocks. The old rock base is beneath the Quaternary deposits.

1.3.1.5 Sanandaj-Sirjan Unit

This Sanandaj-Sirjan sedimentary-structural unit is located immediately after the high Zagros and parallel to that in the same direction. From the geographical point of view, the Sanandaj-Sirjan is considered as part of Zagros Mountains but from geological point of view this unit is completely different from Zagros according to lithological properties. This unit plays the role of a geological buffer zone between Zagros and central Iran. This metamorphic unit is separated from central Iran with some tectonic depressions such as Urmia Lake, Mighan, Gavkhouni, Harat-Marvast, and Sirjan playa. As one of the most active structural zones in Iran, the Sanandaj-Sirjan had important magmatism and metamorphic phases (Darvishzadeh and Mohammadi 1995; Khosrotehrani and Darvishzadeh 1984).

1.3.1.6 Central Iran

The central Iran is one of the complicated sedimentary-structural units of the country. According to Stöcklin (1968) map, this zone is limited to Alborz from north, Sanandaj-Sirjan from west and south and Lut block from east. In this unit, we can see the oldest metamorphic rocks (Precambrian) and active and semi-active volcanos (Darvishzadeh and Mohammadi 1995). As the oldest part of microcontinent of Iran, the central Iran experienced the enormous effects of different geological events. Western fringe of central Iran is confined to magmatic belt of Urmia-Dokhtar or Sahand-Bazman. This part of central Iran, about 150 km wide, is extended from northwest to southeast and separated from Sanandaj-Sirjan unit with some tectonic depression (Khosrotehrani and Darvishzadeh 1984).

1.3.1.7 East and Southeast Iran

The unit of east and southeast Iran is located at the east and southeast part of the country. This unit is divided into three subunits of Nehbandan-Khash (flysch) in the East margin of Iran, Lut block in the middle southeast part, Makran (Mokaran) in the southeast part of Iran, and northern areas of Oman Sea.

1.3.1.8 Nehbandan-Khash or Flysch Unit

The Nehbandan-Khash is located at southern part of east Iran between Lut block and the political boundary between Iran, Afghanistan, and Pakistan (Helmand block). The Nehbandan-Khash unit, 200 km wide, is extended about 800 km from north to south. This unit is also called ophiolite zone because it is rich in ophiolite-melange rocks. There are copious marine flysch rocks very thick in depth which are intensively influenced by tectonic activities (Ghorbani 2014). The intrusive and extrusive volcanic rocks are greatly concentrated in this unit. Indeed, Taftan Volcanos erupted within and over the flysch rocks of this unit (Khosrotehrani and Darvishzadeh 1984).

1.3.1.9 Lut Block

Lut block, about 900 km long (and 125–200 km wide), is shaped in the east fringe of Central Iran Microcontinent (Aghanabati 2004), above the Makran active subduction zone. Its eastern border is limited to Nehbandan Fault and flysch Basin and its western border is restricted to Nayband Fault and Tabas Block. According to tectonic map (Stöcklin and Nabavi 1973), the northern and southern boundaries of the Lut block are limited to two depressions, one in the south margin of Kashmar City (as the north boundary) and the other as Jazmuriyan Depression (as the south boundary), respectively.

Stöcklin (1968) believed that this block is composed of two eastern and western sections separated from each other by Shotori Mountains.

1.3.1.10 Makran (Mokaran)

Makran or Mokaran Mountains in topographic point of view is considered as the trail of the Zagros Mountains but in geological point of view it is completely different (Jadari Eyvazi 1995). The Makran Unit is limited to Jazmuriyan Depression from the north and limited to Minab fault, with N–S orientation, from the west. Berberian (2014) identified that this unit is Makran Accretionary Wedge and Subduction Zone and suggested that the Makran covers coastal areas, about 900 km long and 125–200 km wide, across Iran and Pakistan, above the Makran active subduction zone. This unit contains several faults and trust in its northern part and E–W orientation. There are ophiolite series along these faults.

1.3.1.11 Alborz

Alborz mountainous belt is developed as a strip-like wall in the southern ring of Caspian Sea shoreline with W–E direction parallel to the arc of Caspian Sea. As said earlier, Alborz zone is divided into three subunits. In a different classification, border of Alborz is not identical. In some other classifications, Azerbayjan and Koppeh Daghs (northwest and northeast Iran) are separated from Alborz unit.

1.3.1.12 Eastern Alborz and Koppeh Dagh

According to some geologists, the Koppeh Dagh unit divided into two different subunits, Binaloud and Koppeh Dagh-Hezar Masjed (Nabavi 1976). The Binaloud is a transitional zone in which we can find both the properties of Alborz and Central Iran (Fig. 1.10). The sedimentary-structural unit of Koppeh Dagh-Hezar Masjed is developed

Fig. 1.10 Landscape of Koppeh Dagh unit

from east Alborz to the political boundary of Iran-Turkmenistan and limited to Turan Plateau (Khosrotehrani and Darvishzadeh 1984). Stöcklin (1968) suggested that this unit is highly different from Alborz in a variety of structural characteristics. Berberian (2014, 155) stated that "the Koppeh Dagh forms a NW–SE separating the Turan shield (Turkmenistan; part of the stable Eurasia Shield) in the north from the Alborz, Binalud, and north Central Iran in the south. Structurally, the rocks of the Koppeh Dagh are distinct from those of Alborz, Central Iran, and Zagros and belong to the Turan shield".

1.3.1.13 Central Alborz

The central Alborz unit is extended from Ghazvin City to Semnan. This unit is divided into two distinguished units of Gorgan-Rasht (northern Alborz) and Southern Alborz (Darvishzadeh and Mohammadi 1995). Northern Alborz is formed of coastal areas in southern part of Caspian Sea and northern part of north Alborz fault covered with Quaternary sediments including fluvial, coastal, and deltaic deposits. Central Alborz is separated from Gorgan-Rasht by Alborz fault. The highest point of Iran, Damavand Volcano peak, up to 5671 m high, is located in this unit (Fig. 1.11). As mentioned earlier, the only active mountainous glacier (Alam kuh) of Iran about 4850 m high is located in this unit.

1.3.1.14 Western Alborz and Azerbaijan

Nabavi (1976) believed that western Alborz and Azerbaijan are considered as different units. On the contrary, Stöcklin (1968) stated that most areas of Azerbaijan are pieces of central Iran. This unit is restricted from north by Alborz fault and from south by Semnan fault and from the west by Tabriz-Urmia fault (Khosrotehrani and Darvishzadeh 1984). This unit is influenced by metamorphism. The Takab and Urmia are the

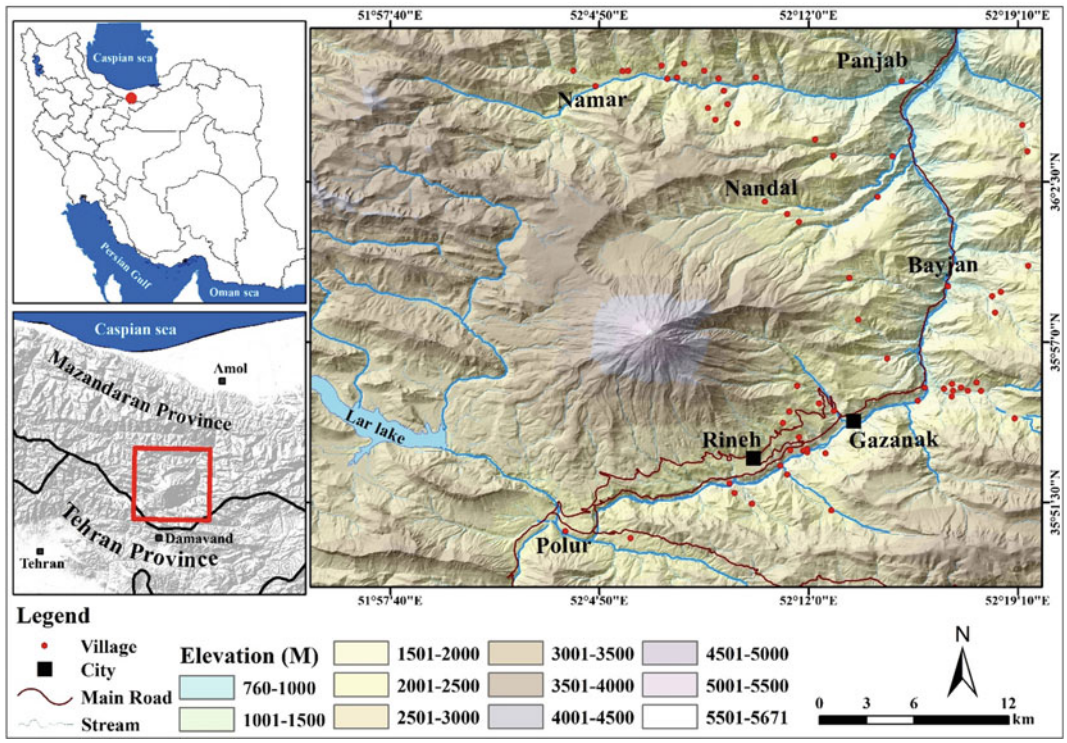

Fig. 1.11 Middle part of central Alborz (Damavand peak)