Chapter 2
A Summary of Geology of Iran

Abstract This chapter presents an abridged description of the geology of Iran covering the following areas:

- Stratigraphy of Iran from Late Precambrian to Quaternary along with a brief introduction to various lithostratigraphic formations
- Structural units of Iran, orogenic phases and major faults that played a significant role in the geologic history of the country
- Magmatic activities of Iran including igneous phases, intrusive and extrusive rocks, and classification of ophiolitic complexes

The chapter provides the reader with a good knowledge about general geological characteristics of Iran in an abridged form.

Keywords Geology of Iran • Faults of Iran • Stratigraphy of Iran • Magmatism of Iran • Structural units of Iran • Orogenic phases of Iran • Basement of Iran

From a global tectonic point of view, Iran is part of the Alpine–Himalayan orogenic belt that extends from Atlantic Ocean to Western Pacific. Most European and Asian geologists believe that this belt represents the great Tethys sea once located between two large continents, Gondwana and Laurasia, during Paleozoic–Mesozoic eras.

For more detailed information on the geology of Iran, it is recommended to refer to a geology of Iran (Ghorbani 2012a).

2.1 Structural Divisions of Iran

Iran has been divided into several structural units, each characterized by a relatively unique record of stratigraphy, magmatic activities, metamorphism, orogenic events, tectonics, and overall geological style. Systematic geological studies in Iran started in late 1960s with the establishment of the Geological Survey of Iran. The tectonic

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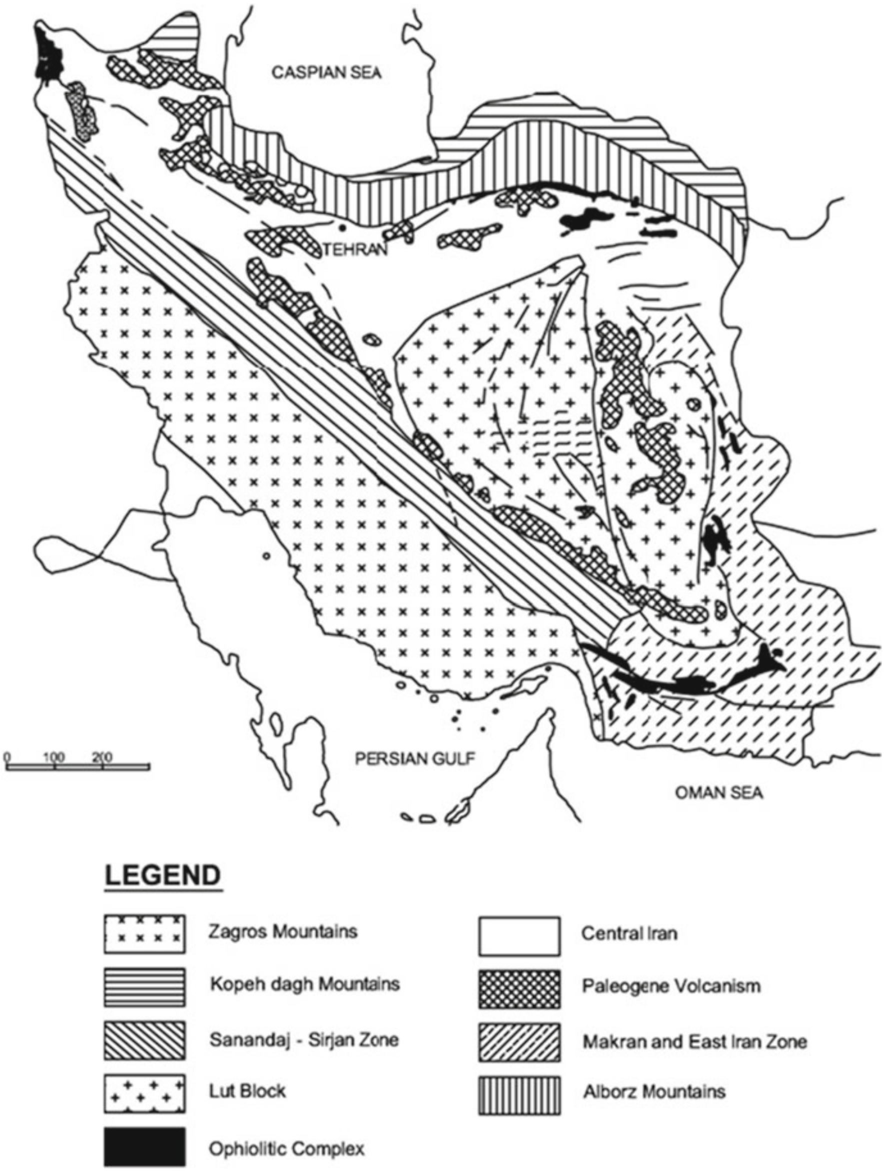


Fig. 2.1 Structural zones of Iran (Stöcklin 1968)

and structural setting of Iran in the Alpine–Himalayan orogenic belt, and the structural evolution of Iran, has been the focus of many studies.

Using mostly the NIOC database, Stocklin and Nabavi (1973) were the first to publish a "Tectonic Map of Iran." The authors divided Iran into 10 structural zones (units) based on certain geological features (Fig. 2.1). This structural division remained a reference for Iranian geologists for almost three decades. However, the new observations and findings require a revision to this structural scheme. Following this structural division by Stocklin and Nabavi, some other structural divisions were presented that are cited in following section related to Central Iran. These newer structural schemes are mostly derived and inspired by the very first structural division presented by Stocklin.

In recent years, new interpretations and models have been offered regarding the geological setting of Iran (Nabavi 1976; Eftekharnejhad 1980; Nogol-e-Sadat 1993; Alavi 1993; Houshmand-Zadeh 1998; Aghanabati 2004). The following is a combined summary of the available data on various structural zones of Iran:

2.1.1 Central Iran

Located as a triangle in the middle of Iran, Central Iran is one of the most important and complicated structural zones in Iran. In this zone, rocks of all ages, from Precambrian to Quaternary, and several episodes of orogeny, metamorphism, and magmatism can be recognized. There is not a consensus regarding the boundaries of Central Iran.

According to Stocklin (1968), Central Iran is bordered by the Alborz Mountains in the north, Lut Block in the east, and Sanandaj–Sirjan in the south-southwest, whereas Nabavi (1976) considers the northern part of the Lut block as part of the Central Iran. Nogol-e-Sadat (1993) extends the frontiers to the northeast as well as Eastern Iran and presents new subzones in his classification. Based on tectono-sedimentary features, Aghanabati (2004) believes Central Iran and Sanandaj–Sirjan are parts of the central domain (Figs. 2.2, 2.3, 2.4 and 2.5).

2.1.2 Sanandaj–Sirjan

This zone is located to the south-southwest of Central Iran and the northeastern edge of Zagros range. In north and northeast, this zone is separated from Central Iran by depressions like Lake Orumiyeh, Tuzlu Gol, and Gavkhouni and faults like Shahr-e-Babak and Abadeh, and to the south-southwest by the main thrust fault of Zagros. A striking feature of this zone is the presence of immense volumes of magmatic and metamorphic rocks of Paleozoic and Mesozoic eras.

As far as the trends, and particularly the folding style is concerned, some researchers consider the Sanandaj–Sirjan Zone similar to Zagros; however, considerable differences exist in rock types, magmatism, metamorphism, and orogenic events. There are some similarities between Sanandaj–Sirjan and Central Iran.

2.1.3 Zagros

This zone extends from Bandar Abbas in the south to Kermanshah in the northwest and continues through to Iraq. Zagros is in fact the northeastern edge of the Arabian plate.

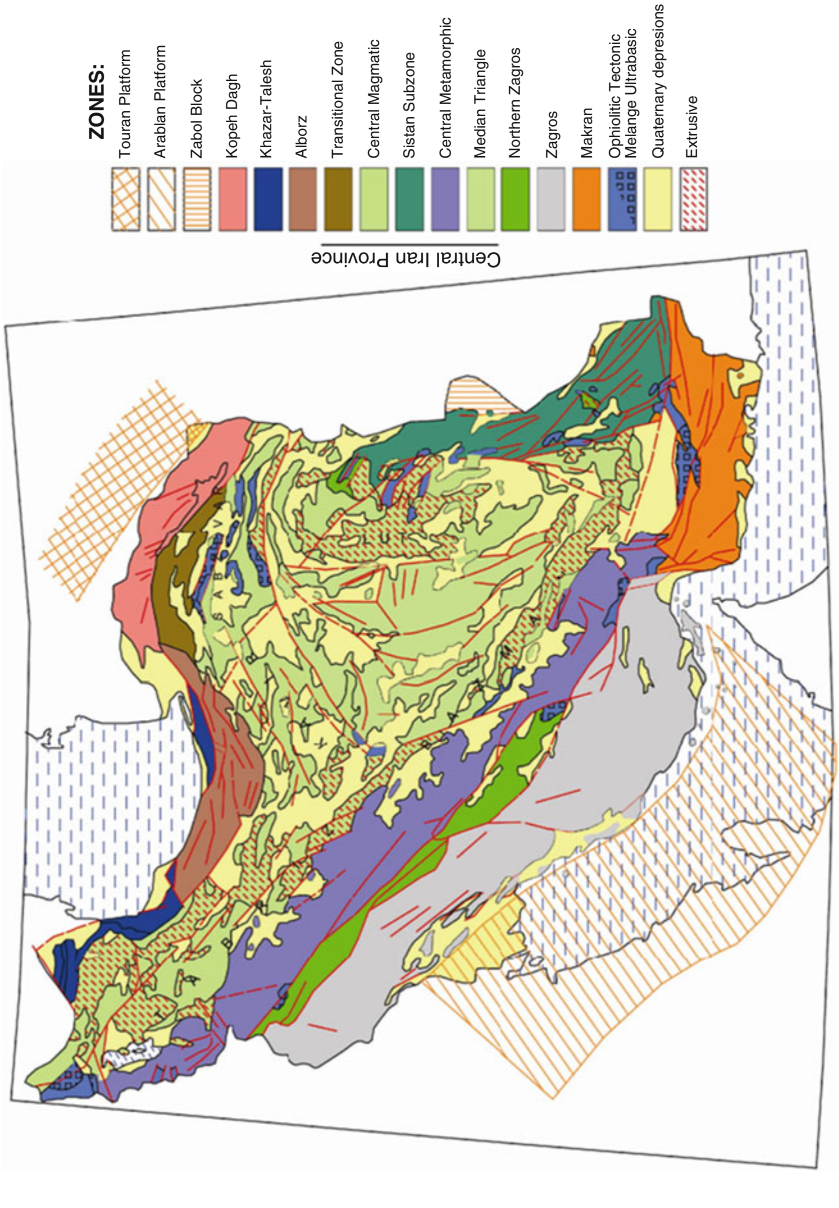


Fig. 2.2 Layout of main structural zones (Nogole-Sadat 1993)

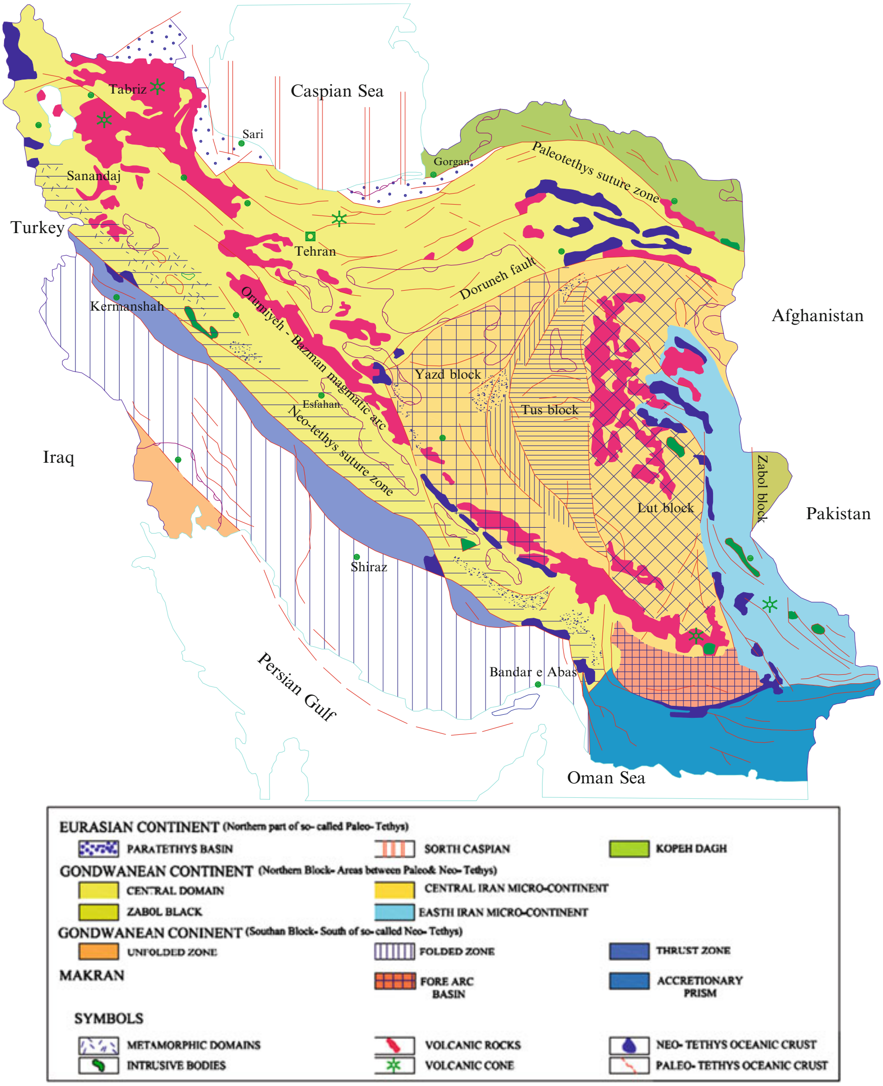


Fig. 2.3 Important tectono-sedimentary areas of Iran (Aghanabati 2004)

Some important features of Zagros include:

– Absence of magmatic and metamorphic events after Triassic
– Low abundance of the outcrops of Paleozoic rocks
– Structurally, it consists of large anticlines and small synclines
– Continuous sedimentation from Triassic to Miocene with negligible hiatuses

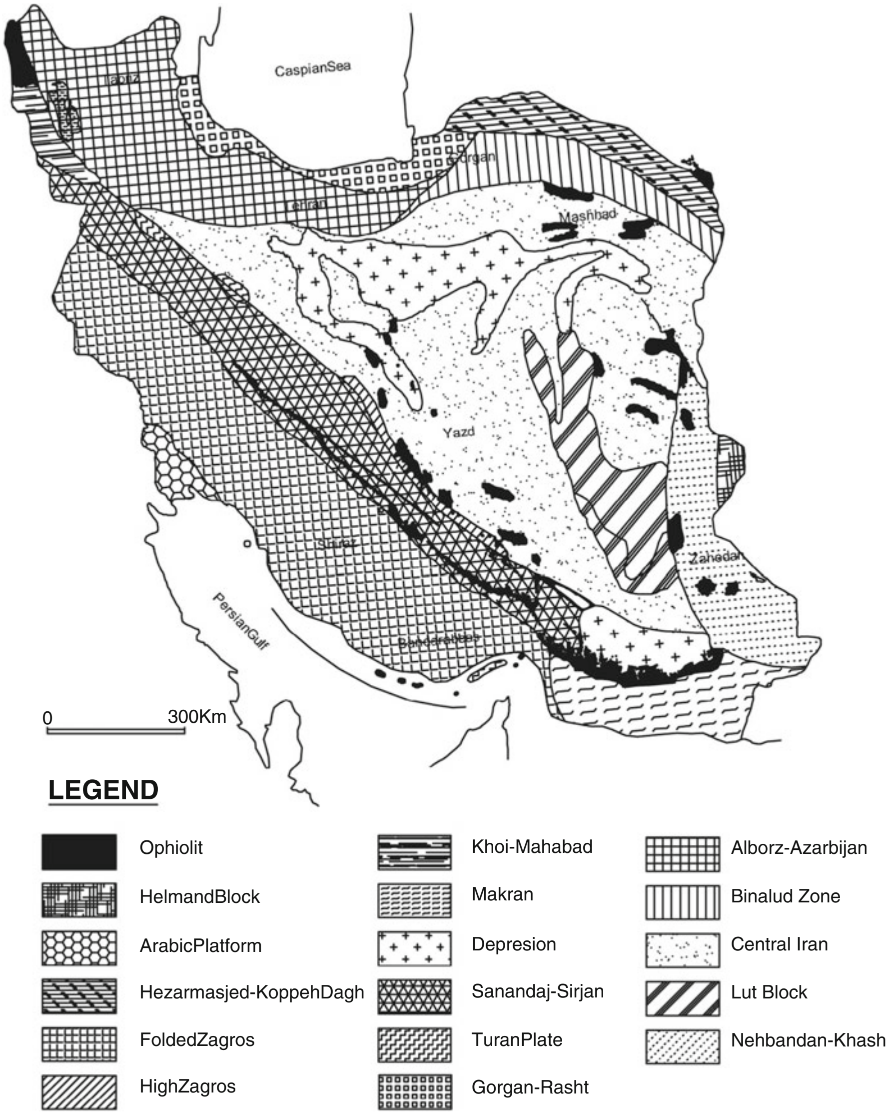


Fig. 2.4 Structural zones of Iran (Nabavi 1976)

2.1.4 Alborz

Alborz range is located in northern Iran, parallel to the southern margin of Caspian Sea. Alborz is characterized by the dominance of platform-type sediments, including limestone, dolostone, and clastic rocks. Rock units from Precambrian to Quaternary have been identified, with some hiatuses and unconformities in Paleozoic and Mesozoic. Unlike its northern and southern boundaries, (Caspian Sea and Central Iran, respectively) there is not a consensus regarding the eastern and the

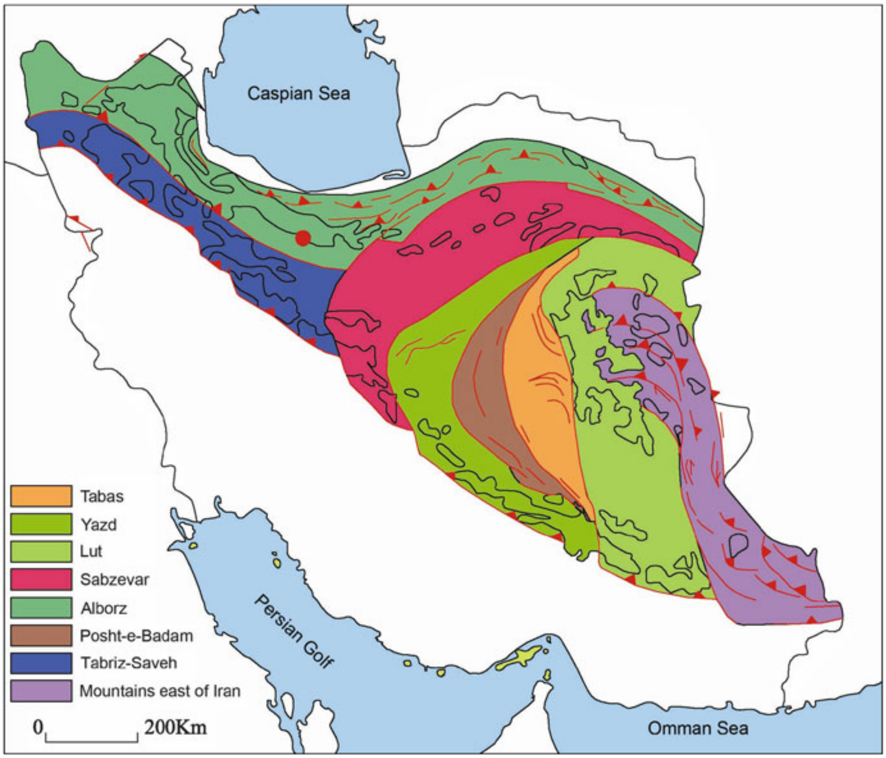


Fig. 2.5 Subzones in Central Iran presented by Alavi (1991)

western limits of Alborz. Binaluod range in the east, although a continuation of Alborz, bears features comparable to those of Central Iran.

Nabavi (1976) considers Azerbaijan in the west as part of Alborz, but Stocklin (1968), taking into account the structural features, considers this zone as an anticlinorium in the northern margin of Central Iran with comparable stratigraphic and structural features. It is evident that the geological evolution of Alborz is different from that of Azerbaijan during Cenozoic.

2.1.5 Azerbaijan

There is no agreement regarding the geological setting of Azerbaijan. Stocklin (1968) considers most of Azerbaijan as belonging to Central Iran. According to the author, the northeastern corner could be included in Alborz and the southeastern part in Sanandaj–Sirjan. Nabavi (1976) believes that most of Azerbaijan lies in a zone called Azerbaijan–Alborz, and as he indicates, this zone is bounded in the north by Alborz fault, in the west by Tabriz–Urumiyeh fault, and in the south by Semnan fault. The eastern boundary with Binaluod Zone is still controversial.

In a broader view, Innocenti et al. (1982) picture two orogenic belts to explain the structural units of Western Iran, Azerbaijan, and Eastern and Central Turkey:

– Pantus, minor Caucasus, and Alborz Belt (Azerbaijan)
– Taurus–Central Iran Belt to the south

According to the said authors, northern part of Azerbaijan is included in Caucasus and Pontus Mountains in Turkey and the Southern Azerbaijan is comparable with Central Iran and Western Iran and extends to Taurus Mountains in Turkey.

The significant structural event occurring in Early Devonian was accompanied by faulting and fragmentation that led to a different sedimentary facies in Azerbaijan (Eftekhar Nezhad 1975b). This orogenic episode generated the Tabriz fault, extending in a NW–SE direction from Zanjan depression to the northern mountains of Tabriz (Mishu, Morou) and northwest of Azerbaijan and Caucasus. This event divided Azerbaijan into two blocks (Innocenti et al. 1976), one block in northeast with subsidence and sedimentation in Early Devonian and the other in southwest which remained high until Late Carboniferous.

2.1.6 Eastern Iran

Eastern Iran can be divided into two parts:

– Lut Block
– Flysch or colored mélange of Zabol–Baluch Zone

Lut Block: Located to the west of Zabol–Baluch Zone, Lut Block is the main body of Eastern Iran. Lut Block extends for about 900 km in a north–south direction. It is bounded in the north by Dorooneh fault and in the south by Jazmourian Depression. In the east, it is separated from Flysch Zone by the Nehbandan fault, whereas the western boundary with Central Iran is Nayband fault and Shotori Mountains. The oldest units include upper Precambrian–Lower Cambrian schists overlain by Permian limestone and other Paleozoic sedimentary rocks.

Flysch Zone (Zabol–Baluch): This zone is located between Lut Block to the west and Helmand (in Afghanistan) to the east. In contrast to Lut Block, the Flysch Zone is highly deformed and tectonized and consists of thick deep-sea sediments like argillaceous and silicic shales, radiolarite, and pelagic limestone and volcanic rocks such as basalt, spilitic basalt, diabase, andesite, dacite, rhyolite, and subordinate serpentinized ultramafic rocks. The basement is likely composed of an oceanic crust. Most rock units in this zone fall into three main groups:

– Flyschoid sediments
– Volcanic, volcanosedimentary, and intrusive rocks
– Ophiolitic series

2.1.7 Southeastern Iran (Makran)

This zone is located to the south of Jazmourian depression. Its western boundary is Minab fault; to the south, it is restricted by Oman Sea, and to the east, it extends into Pakistan. The northern part is characterized by dominance of east–west trending faults, Bashagard fault being the most important one. Along these faults lies large section of ophiolite series. The oldest rocks in this zone are the ophiolites of late Cretaceous–Paleocene overlain by a thick sequence (about 5,000 m) of sandstone, shale, and marl. The whole sequence is deformed prior to Early Miocene. Thick sequence of Neogene rock units, in excess of 5,000 m, covers the older series (Nabavi 1976).

2.1.8 Kopet Dagh

This basin is located in the northeastern Iran. From Middle Jurassic, it was covered with a vast continental shelf sea (Berberian and King 1981). In this period of time and due to transgression as well as rapid subsidence basin, the western part became deeper. In this basin, a thick sequence of continuous marine and continental sediments was deposited (about 10 km). No major sedimentary gap or volcanic activities during Jurassic to Oligocene have ever been reported. This sedimentary complex provides suitable conditions for accumulation of hydrocarbons. Kopet dagh sedimentary rocks were placed in their current position due to uplifting at the end of Miocene.

2.2 Ophiolite Series and Ultramafic Rocks of Iran

Ophiolite series and ultramafic rocks have a widespread occurrence in Iran and can be grouped as follows:

– Ultramafic and mafic units of Late Precambrian–Early Cambrian. Although comparable to modern ophiolites, these rocks do not display all typical features of an oceanic crust. The term "old ophiolite" might be a misnomer. These rocks are widespread in Takab and Anarak Regions. They might be representing a protorift.
– Ultramafic and mafic rocks of Upper Paleozoic. These rocks occur as metamorphosed as well as non-metamorphosed bodies in some areas like Fariman, Shanderman, and Asalam. These rocks display many typical features of modern ophiolites.

Ophiolite series of Early Cretaceous–Paleogene age: These rocks show typical features of ophiolitic sequences and are thought to be associated with the closure of

Neotethys. These ophiolite series are widespread in Iran. Some of the more important locations include:

- Kermanshah–Neyriz–Oman Belt
- Makran (south of Jazmourian)
- Ultramafic–mafic rocks related to Flysch Zone in Khash–Nosrat Abad–Birjand Belt
- Ultramafic and mafic rocks north of Dorooneh fault, Torbat Jam–Torbat Heidarieh–Sabzevar–Fariman Regions
- Central Iran–Naeen–Baft–Shahr Babak
- Khoy–Maku

Ultramafic and mafic rocks also occur in association with large gabbroic intrusions. This type probably resulted from differentiation in a large mafic magma chamber, comparable to those of the layered mafic intrusions. Examples occur in Sero, Urumiyeh, and in Masooleh that are Late Cretaceous to Lower Oligocene in age.

2.3 Basement Rocks

Taking into account the available data on the geology of Iran and Middle East, and comparing it with Arabian basements, it seems that stabilization of the basement in Iran occurred in the Late Proterozoic to Early Cambrian. This is supported by similar Gondwanic features in both Iranian and Arabian basements.

It is believed that the Arabian shield was the continuation of Mozambique in Eastern Africa prior to the development of Red Sea (BRGM and USGS and some German teams) (Geodynamic Report, GSI 1983).

The cratonization happened transitionally from Africa toward Iran as evident from the age of the basements; Central Africa has a basement of Late Archean–Early Proterozoic while in the Northern Africa, there is no Archean basement; besides the extent of Precambrian domains reduces from Central Africa toward north. Some authors (Hushmandzadeh 1998) believe that cratonization of Iran has been due to Baikalian, Asynitic, or Pan-African orogenies.

The oldest known sedimentary unit in Iran is Kahar Formation, which is well exposed in Alborz and Azerbaijan. Kahar consists of shale, dolomitic sandstone, and tuff metamorphosed to slate and phyllite (B. Hamdi 1995). The uppermost layers show an age of about 650 million years based on the paleontology and stratigraphic evidence; the basal layers are thought to be as old as 800 my (Ghorbani 2012a, b). Based on field observations, an older age has been suggested for some metamorphic units in Central Iran and Takab Regions (e.g., Robat Poshtebadam, Saghand in Central Iran, Mahneshan in Azerbaijan; Haghipour 1974; Alavi Naeini et al. 1976); however, this is not supported by new data. The oldest rocks in Iran, based on the radiometric ages, are as old as 900 million years (Hushmandzadeh, unpublished). This is the time when Doran-type granites and Gharehdash series formed.

Comparing the geology of Iran and the Arabian Craton and concerning the intrusion of granitoid rocks as an essential component of the continental crust, it can be argued that cratonization of Iranian platform occurred in the Late Precambrian–Early Cambrian, prior to sedimentation of Lalun sandstone.

2.4 Summary of Stratigraphy of Iran

2.4.1 Precambrian

It was believed earlier that Precambrian rocks older than 1.5 billion years had extensive outcrops in Iran. However, more recent data suggest that Precambrian domains are smaller in exposures and that they are all younger than 900 million years. In North and Central Iran, Kahar and Gharehdash Formations and the lower half of the Soltanieh Formation are of Precambrian ages.

According to Hamdi (1985), the oldest rocks in Iran belong to the Kushk Series consisting of clastic sediments, acidic volcanic, tuff, and carbonates (mainly dolomite). Other formations of Late Precambrian–Early Cambrian ages include Rizu volcanic-sedimentary Formation, Dezu and Tashk Formations, Aghda limestone, Kalmard Series, Shorm Beds, and Anarak metamorphic units. The sedimentary facies of Precambrian–Lower Cambrian rocks in Northern Iran is different from that of Central Iran.

2.4.2 Paleozoic

Following the Pan-African orogenic episode, shallow marine sediments formed in Late Vendian. The influence of the orogenic episode is evident at the base of the Vendian sediments. Deposition of shallow marine sediments covered large areas in Iran during Paleozoic (e.g., Alborz, East of Iran, Zagros; Alavi-naini 2009).

There is strong stratigraphic evidence that transition from Vendian to Lower Cambrian was a progressive one, without hiatuses; there is no evidence for any orogenic or epeirogenic movements in Iran at this time (e.g., south of Zanjan, Valiabad Chalus, Shahin Dezh; Hamdi 1995; Alavi-naini 1993).

Early Cambrian started with an alternation of shale, phosphate-bearing limestone, and dolomite sitting conformably and transitionally over Vendian dolomites. Transition from Soltanieh Formation to Barut, Zaigoon, and Laloon Formations is very difficult to recognize in the field (Alavi-naini 1993).

Middle Cambrian is characterized by uplift and regression; however, a renewed progression at this time led to the deposition of Mila and Kuhbanan Formations, consisting of limestone, dolomite, and shale, over older units. These formations bear trilobites and brachiopods of Middle and Late Cambrian (Alavi-naini 1993). In some areas, the Late Cambrian carbonate facies turns transitionally into Ordovician graptolite shales, known as Lashkarak Formation in Alborz, Shirgasht

Formation in Central Iran and Ilbeyk and Zardkuh Formations in Zagros. In Kalmard area, Ordovician sediments are sitting on the Vendian sediments through an angular unconformity (Aghanabati 2004).

In Late Ordovician, most parts of Iran were affected by epeirogenic movements (e.g. Alborz; Alavi-naini 2009); this coincides with Caledonian orogeny in Europe and some other parts of the earth. The epeirogeny caused a distinct hiatus at the Ordovician–Silurian boundary. Where present, the Silurian rocks in Iran consist mainly of limestone, sandstone, shale and volcanic materials, known as Niur Formation in Central Iran.

The Lower Devonian rocks have been reported from several localities in Central Iran (e.g., Tabas, Sourian, Kerman, Zagros; Ghorbani 2012a, b); however, they seem to be missing in Alborz and parts of Zagros. Upper Devonian is characterized by marine transgression, particularly in Alborz, that extends into Lower Carboniferous. With exception of Tabas area, no record of Middle Carboniferous marine deposits has yet been discovered in Iran (Ghorbani 2012a, b). Upper Carboniferous deposits are not significantly present in Iran and have only been identified in several localities from index goniatites (Alavi-naini 1993). After a general regression and a distinct hiatus in Upper Carboniferous, Permian marine transgression deposits cover most parts of Iran (e.g., Alborz, Zagros, Central Iran; Aghanabati 2004). The Permian sediments are represented by Dorood sandstones, Ruteh and Nesen limestones in Alborz.

2.4.3 Mesozoic in Iran

The Lower Triassic sediments in Iran are mainly of shallow marine or continental shelf nature (e.g., Doroud sandstones and Elika dolomites in Alborz, Sorkh shales and Shotori dolomites in Central Iran; Aghanabati 2004; Alavi-naini 2009). A continuous Permian–Triassic sequence has been reported from several areas in Iran, including Jolfa (northwest of Iran), Abadeh (Southern Central Iran), and Southern Urumiyeh (the continuation of Taurus in Turkey), north of Kandevan and Southern Amol.

Transition from Middle to Upper Triassic coincides with Early Cimmerian orogenic episode, which led to the segmentation of the sedimentary basin into three sub-basins: Zagros in south and southwest, Alborz in north, and Central Iran (Aghanabati 2004).

The Lower Jurassic rocks conformably overlie the Upper Triassic units; so are the Early Cretaceous deposits over the Upper Jurassic strata (e.g., Zagros; Motiei 1993).

In North and Central Iran, the Upper Triassic and Lower–Middle Jurassic sediments have a detrital nature, consisting mainly of shale and sandstone with thicknesses varying from a few meters to more than 3,000 m. The presence of plant remains and coal beds suggest a continental or lagoon environment for the deposits (Aghanabati 1998). The Cretaceous deposits, characterized by diverse sedimentary facies, are widespread all over Iran. In Late Cretaceous, tectonic movements related to the Laramide orogeny affects most parts of Iran, leading to uplift, folding, and faulting (Ghorbani 2012a, b). This is a prelude to significant developments in the geological evolution of Iran.

2.4.4 Tertiary

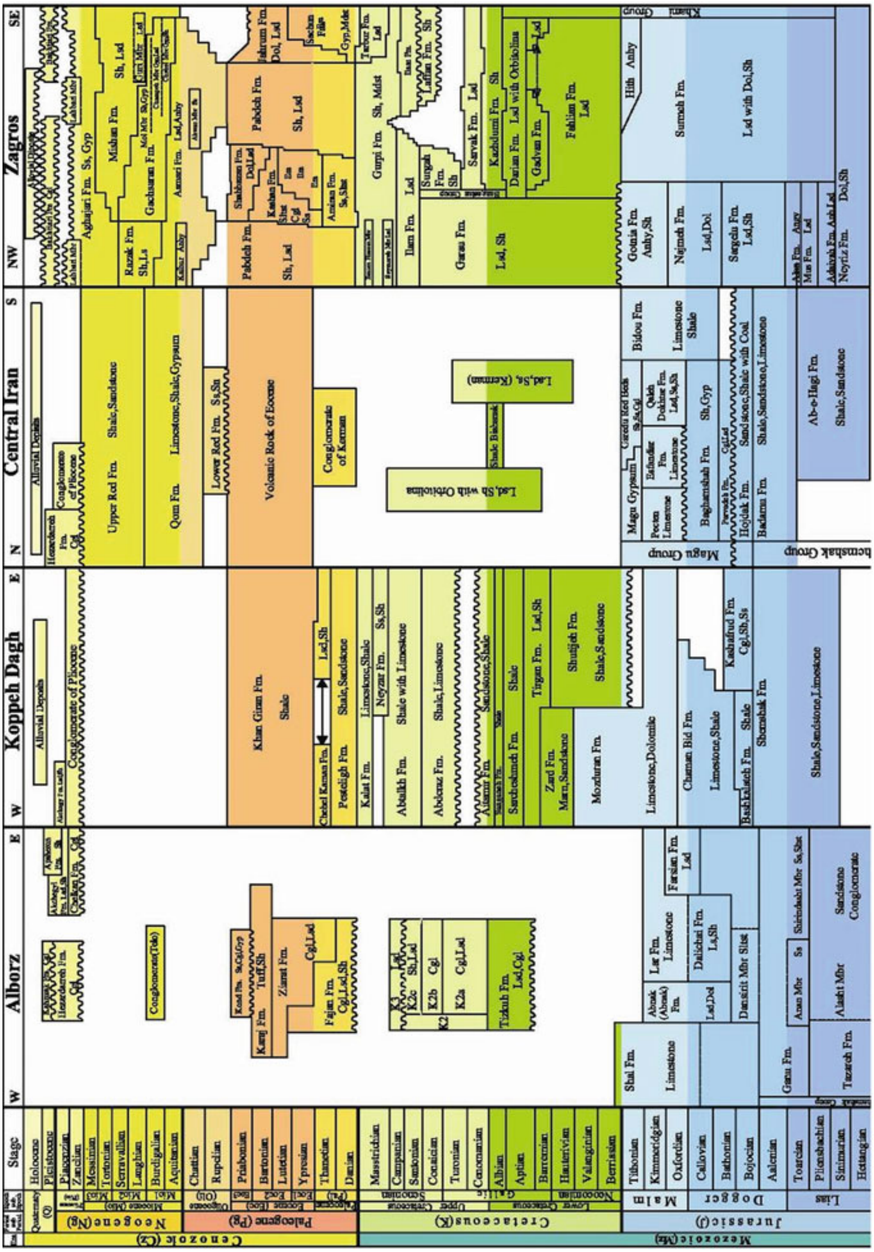
The Cretaceous–Paleocene boundary is characterized by striking changes in sedimentary environments (e.g., Alborz, Central Iran; Hajian 1996). An unconformity has been reported from many locations in Iran. Both continuous and discontinuous transitions have been discovered between Paleocene and Eocene strata; as is the case with Eocene and Oligocene (e.g., Central Iran; Hajian 1996). The Oligocene and Miocene stages are characterized by rapid subsidence, deposition, and facies changes in both marine and continental sedimentary basins (e.g., Mahneshan and Halab south of Zanjan; Rahimzadeh 1994). Oligocene sediments in most parts of Iran are of shallow marine character, turning into marine facies in Upper Oligocene through Lower Miocene (e.g., Qom; Rahimzadeh 1994). The Middle–Upper Miocene sediments are mostly of continental nature.

2.5 Stratigraphic Succession in Various Structural Divisions

A comparison of stratigraphic records in various structural divisions of Iran is shown in Fig. 2.6.

2.6 Overview of Distribution and Nature of Magmatic Rocks in Iran

Magmatic rocks of all ages, from Precambrian to Quaternary, are widespread in Iran (e.g., Doran granite, Zarigan–Narigan granite, Torghabeh granite, Ghaen granite, Chaghand gabbro, Alvand granite, Natanz granite; Ghorbani 2012a, b). A correlation exists between distribution of magmatic rocks and certain types of ore deposits (e.g., iron deposits in Bafgh related to Zarigan–Narigan-type granites, Mazraeh copper deposit related to Sheyvar–Daghi granite, Sarcheshmeh porphyry deposit related to Sarcheshmeh porphyry body; Ghorbani 2002b). Several episodes of magmatic activities have been identified in Iran. These episodes include:


Stage
Alborz
Koppeh Dagh
Central Iran
Zagros
Cenozoic (Cz)
Mesozoic (Mz)
Neogene (Ng)
Paleogene (Pg)
Cretaceous (K)
Jurassic (J)

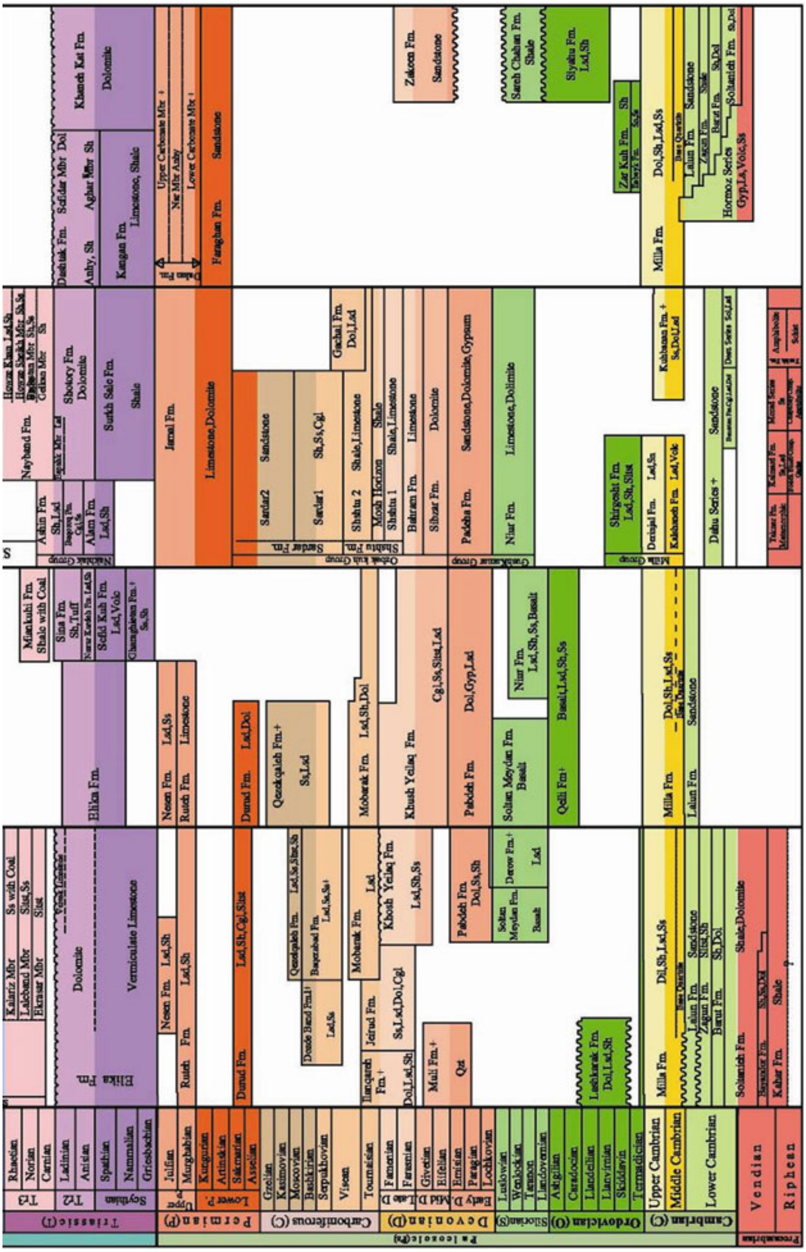


Fig. 2.6 Lithostratigraphic succession in various Structural Divisions of Iran (by Geological Society of Iran)

2.6.1 Magmatic Rocks of Upper Precambrian–Lower Cambrian

Volcanic and plutonic rocks with an age of 630–530 m.y. have been reported from many localities in Iran, particularly in Central Iran and Azerbaijan (Houshmand-Zadeh 1998; Ramezani and Tucker 2003). These magmatic rocks seem to be related to the Pan-African tectonic-magmatic episode. Most magmatic rocks of this time bear an alkaline nature (Ghorbani 2012a, b). The following magmatic series can be attributed to this phase:

- Doran-type intrusions in Azerbaijan.
- Narigan and Zarigan-type intrusive bodies extend from Anarak to Bafgh and Kuh Banan.
- Volcanic rocks, mostly of rhyolite composition, in Ghareh Dash, Azerbaijan.
- Volcanic rocks associated with Kushk Series in the Bafgh area.
- Volcanic rocks of Rizu, Dezu, and Kushk Formations in Central Iran.
- Most Precambrian metamorphic rocks of greenschist or even amphibolite facies, such as in Takab and Anarak areas, seem to have originally been volcanic materials, either lava or pyroclastic rocks.

2.6.2 Lower Paleozoic

Magmatic rocks of this time have been reported from many areas in Iran. Examples include basaltic rocks of Shahrud and Khosh Yeilagh, andesitic-basaltic units of Niur Formation in Central Iran, and tuffaceous materials in the upper parts of Mila Formation in Eastern Iran (Aghanabati 2004; Ghorbani 2012a, b).

2.6.3 Upper Paleozoic

Volcanic rocks of andesitic-basaltic composition accompany Upper Paleozoic sedimentary strata in many areas all over Iran. Basaltic rocks associated with Jeyrud Formation of Upper Devonian are a typical example (Aghanabati 2004; Ghorbani 2012a, b).

There is strong evidence for significant magmatic activities in Late Paleozoic–Early Mesozoic (Early Permian to Early Jurassic) in Iran (Ghorbani 2012a, b). Examples include:

- Magmatic rocks in the Southern Sanandaj–Sirjan (granites and gabbros of Sirjan area) and volcanic rocks of Songhor Series in Northern Sanandaj–Sirjan
- Ultramafic and mafic rocks and their metamorphosed equivalents in Eastern Iran (Fariman area), Taknar Series, Gorgan schists, Shanderman mafic/ultramafic metamorphic series

2.6.4 Mesozoic

The Mesozoic magmatic rocks are associated with Cimmerian and Laramide orogenic events that caused continental and oceanic rifting, followed by closures and collisions in vast areas of Iran (e.g., Sanandaj–Sirjan; Omrani 2008). The Mesozoic magmatic rocks can be divided into three groups:

Volcanic rocks: These rocks occurred mainly as a result of extension or tension related to the continental rifting, or subduction of the developed oceanic lithosphere under the continental lithosphere (e.g., Central Alborz for continental rifting; Ghorbani 2012a, b; Saghez-Sanandaj axis for subduction, Tarkhani 2010).

Intrusive rocks: Many intrusive bodies of mafic to granitic composition, with ages varying from early Triassic to Late Cretaceous, have been identified in Iran (e.g., Boroujerd–Shamsabad axis; Masoudi 1997; Ahmadi-khalaji 2007).

In Triassic–Jurassic, volcanic rocks predominated the plutonic rocks. They are mainly alkaline in nature and are more abundant in Sanandaj–Sirjan. In Jurassic–Cretaceous, intrusive rocks exceed volcanic rocks; a significant number of batholiths in Iran occurred at this time (e.g., Alvand, Shirkuh, Kolah Ghazi, Shahkuh: Ghorbani 2012a, b).

2.6.5 Tertiary

Tertiary is of great concern in Iran because of the great volumes and highly diverse types of igneous rocks and associated mineral deposits. Magmatic rocks of this age are widespread all over Iran, except in Zagros and Kopet Dagh (Metalogenic Map of The Middle East 2011). Data from various structural zones indicate that the volcanic and plutonic activities started in Late Cretaceous, peaked at Eocene, and continued, with short stops, into Quaternary. The Quaternary volcanism produced very high peaks such as Damavand, Sahand, Sabalan, and many others. Some of the more important regions in terms of the Tertiary magmatic activities include:

- Urumiyeh Dokhtar volcanic-plutonic belt
- Azerbaijan
- Tarom–Taleghan
- Central Alborz and its southern margins
- Kavir–Sabzevar
- Kashmar–Torbat-e Jam
- Lut and Kavir, Central Iran
- Sistan
- Bam, Bazman, and Taftan
- East Iran
- Southern Jazmourian–Sabzevaran

The origin and nature of the Tertiary magmatic rocks are controversial. Two different views exist:

1. Intracontinental rifts and aulacogens (Ghorbani 2003a)
2. Subduction of Neotethys oceanic crust under Iranian plate and collision of Arabian and Iranian plates in Late Cretaceous–Paleocene (Ghorbani 2003a, b, c, d, e, f)

2.7 Structural and Orogenic Events in Iran

Several orogenic events have been recognized in Iran, the most important of which being:

2.7.1 Pan-African

This is equivalent to Asynitic in other parts of the earth. This event was associated with metamorphism, magmatism, folding, and faulting during Late Precambrian–Early Cambrian in Iran (e.g., south of Zanjan–Mahabad in Azerbaijan, Bafgh in Central; Nabavi 1976; Ghorbani 1999a). This tectonic phase started with tension or extension leading to the formation of rifts and generation of oceanic crust (e.g., in Takab and Anarak) and ended with folding, closure, metamorphism, growth of the continental crust, and development of regional faults.

2.7.2 Caledonian

There was no considerable folding or faulting related to this event in Iran. Caledonian in Iran is characterized by facies change in sedimentary basins, hiatuses, and epeirogenic movements (e.g., parts of Alborz, Zagros, and Central Iran; Nabavi 1976). This phase, starting from Late Cambrian, caused the marine facies of Barut and Zaigoon Formations to change into the continental facies of Lalun Formation, and continued on to Late Devonian.

2.7.3 Hercynian

The effects of this orogenic episode in Iran can be traced from Late Devonian to Middle Triassic. Due to the scarcity of magmatism, metamorphism, and folding related to this episode, the role of Hercynian in Iran is controversial; Hercynian in Iran is largely represented by extensional rather than compressional tectonics (e.g., Sanandaj–Sirjan; Hosseini 2011).

2.7.4 Early Cimmerian

Early Cimmerian tectonic event is one of the most important ones in the geological history of earth. Many diverse features are associated with this phase, including metamorphism, magmatism, folding, faulting, creation of new basins, and facies change (Ghorbani 2012a, b). This event was associated with compressional tectonics in northern Iran and tensional tectonics in south. There is evidence that the compressional phase was preceded by tension and rift development. The compressional phase, starting in Middle Triassic, finally led to the closure of the paleoteethys (e.g., southeast to southwest of Caspian Sea; Ghorbani 2002a, b, c).

2.7.5 Middle Cimmerian

The operation of this phase in Iran has been controversial. Aghanabti (1998) has recently presented rather strong evidence in support of this tectonic episode in Iran (e.g., Sanandaj–Sirjan and Central Iran).

2.7.6 Late Cimmerian

A significant tectonic event happened in Iran in Late Jurassic–Early Cretaceous times, about 140 m.a. This event is represented by folding, facies changes in sedimentary environments, angular unconformity, magmatism, and metamorphism (e.g., Alborz, Sanandaj–Sirjan, and Central Iran; Aghanabati 2004; Ghorbani 2012a, b).

2.7.7 Laramide

This event, occurring in Late Cretaceous–Eocene, played a great role in the geological evolution of Iran. This event started under a compressional regime, followed by an extension one (Ghorbani 2012a, b; Sadeghi 1999). The compressional regime, that was associated with significant intrusive magmatic activities, led to the closure of the oceanic basins and Neothetyan rifts. In some areas, slices of the oceanic crust have obducted onto the continental margins producing what we now call ophiolite assemblages or colored mélanges (e.g., mostly seen suture zone between Sanandaj–Sirjan and Zagros and alongside Naybandan fault in east of Iran; Nogole-Sadat and Almasian 1993; Nogole-Sadat 1993).

2.7.8 Pyrenean

With regards to the geological evidence, this event was of compressional nature. This tectonic phase is represented by significant changes in the sedimentary environments, plutonism, and metamorphism (e.g., west of Central Iran, south of Central Alborz, Lut; Nabavi 1976).

2.7.9 Pasadenian

Pasadenian is the most important phase in forging current shape of Iran. There are some younger orogenic events that were most likely the continuation of this phase (e.g., Alborz–Azerbaijan axis, Zagros, Central Iran; Tectonic and Seismotectonic Map of Iran 1993; Rahimzadeh 1994).

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