

A BRIEF GEOLOGICAL DESCRIPTION OF NORTH-CENTRAL IRAN

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ABSTRACT

The geological formations in North-central Iran are described and brief references are made to tectonic history.

INTRODUCTION

The region referred to in this volume as North-central Iran is enclosed between 48° and 56° east longitudes and 34° and 38° north latitudes.

For a simplified appreciation of the geology of Iran as a whole, the country can be divided into four major units, separable on the basis of regional differences in tectonic-sedimentary characteristics and metamorphism (Nabavi, 1971).

1. Zagros Ranges – including the High Zagros and foothills.
2. Central Iran s.l., including Azarbaijan and East Iran.
3. Alborz Mountains, from Bandar Pahlavi to Mashhad.
4. Kopet Dagh Range, north of Khorassan.

The area represented by the geological map of North-central Iran accompanying the present report covers the middle sector of the Alborz mountains, the middle-northern part of Central Iran and a small part of the Sanandaj-Sirjan zone in south-western Central Iran.

The Alborz mountains, forming the northern boundary of Central Iran, are a sinuous range of parallel anticlines and synclines. As noted by Stöcklin (1968, p. 1252), the range as a whole “has steep south thrusting on the south and steep north thrusting on the north, but normal faulting and folding have been equally important. The folding intensity gradually decreases towards the Caspian depression”, a major geological feature in an area of thick sedimentary deposits overlying a thick basaltic layer. The Sanandaj-Sirjan zone is an orogenic belt in the northeastern part of the Zagros Ranges and parallel to the Zagros thrust line.

PRECAMBRIAN

The Precambrian (basement complex) rocks are divided into three major groups: metamorphic rocks, non-metamorphic rocks and light-coloured alkali granites.

On lithologic and petrographic grounds it can be postulated that the country was occupied by a sea during Precambrian times and that the sediments accumulated in it were later subjected to a period of very strong deformation, namely the Assyntic or Baikalian orogeny (Nabavi, 1971; Stöcklin, 1968, 1971).

(a) Metamorphic Rocks

The metamorphics of Precambrian age are composed mainly of amphibolite gneiss, mica schist, sericite-chlorite schist, phyllite and marble. The metamorphic rocks transitionally underlie the non-metamorphic rocks.

Some of the metamorphics previously considered to be Precambrian and pre-Devonian in age, are now assigned to the Early Kimmerian orogeny, i.e. to Triassic-Jurassic (e.g., part of the Hamadan metamorphics (Hushmandzadeh and Berberian, 1972); the Gorgan metamorphics are pre-Liassic (Berberian *et al.*, 1973; and the metamorphics of the Torud area are post-Jurassic - pre-Cretaceous (Hushmandzadeh *et al.*, 1973).

(b) Non-metamorphic Green Shales

A green or violet shale-siltstone sequence in North, East and Central Iran is named Kahar Formation (from Kuh-e-Kahar, west of Karaj valley in the central Alborz (Dedual, 1967)). This formation is overlain by Infracambrian formations and itself transgressively overlies the metamorphic rocks.

(c) Doran Granite

This light pink to white felsic granite cuts the metamorphic rocks and Kahar Formation and is overlain by the Infracambrian Bayandor Formation. The granite is named from the village of Doran in the Soltanieh Mountains, south of Zanzan (Stöcklin *et al.*, 1964).

INFRACAMBRIAN

The Precambrian rocks are separated from the overlying Infracambrian and younger formations by an angular unconformity (Assyntic or Baikalian orogeny). The Infracambrian sequences are a group of formations resting on the Baikalian unconformity surface and underlying the Cambrian system. The standard sequence of the Infracambrian group in northern and northwestern Iran comprises in ascending order: the Bayandor Formation, the Soltanieh Dolomite with Chapoghlu Shale Member, the Barut Formation, and the Zaigun Formation. Except for the Bayandor Formation, these rock units can be traced with little variation into Central and East Iran. They are representative of a shallow sedimentary environment and in places contain evaporites such as gypsum and halite (Nabavi, 1971).

During the deposition of the Infracambrian rocks, the whole country was tectonically calm, and only a few epeirogenic movements – reflected in facies changes – took place. Owing to the uniformity of the Infracambrian rocks, both in lithology and tectonic character, throughout Iran, they are usually considered to represent a platform cover (Stöcklin, 1968) deposited after the Baikalian orogenic episode (Nabavi, 1971).

(a) **Bayandor Formation (Infracambrian)**

Named after Kuh-e-Bayandor, south of Zanjan in the Soltanieh Mountains, (Stöcklin *et al.*, 1964).

The formation is composed of dark-purple to wine-red sandstone and sandy to silty shale, with several distinct thin intercalations of dolomite. Only questionable stromatolites and archaeocyatid-like features, probably of an organic nature (Steiger, 1966; Allenbach, 1966), have been reported from this formation. Its stratigraphic position below the Soltanieh Dolomite suggests Late Precambrian (Infracambrian) age.

(b) **Soltanieh Dolomite (Infracambrian)**

Named after the town of Soltanieh, Northwest Iran (Stöcklin *et al.*, 1964).

The formation consists mainly of light-coloured, scarp-forming, massive dolomite, with a thick black shale intercalation in the lower part (Chapoghlu Shale member).

Stromatolites (*Collenia*) are fairly common in the higher dolomite and dolomitic limestone of the formation. The Chapoghlu Shale has yielded the oldest known organic traces in North Iran. These have concentric structures and have been compared by Stöcklin *et al.* (1964) to *Fermoria* sp. of the Vindhyan System of India. These fossils and the stratigraphic position indicate an Infracambrian (latest Precambrian or earliest Cambrian) age (Stöcklin, 1971).

(c) **Barut Formation (Infracambrian)**

Named after Barut-Aghaji village in the northwestern Soltanieh Mountains, 17 km west of Zanjan, Northwest Iran (Stöcklin *et al.*, 1964).

The formation is characterized by an intimate and rather regular alternation of coloured shales, mainly purple, with thin dolomites and limestones. Questionable algal structures (stromatolites, *Collenia*) have been very frequently observed in the limestone intercalations of the formation, especially in its upper part. These and the stratigraphic position of the formation more than 1,000 m below the fossiliferous Middle Cambrian suggest an Early Cambrian or Precambrian age (Stöcklin *et al.*, 1964; Stöcklin, 1971).

(d) **Zaigun Formation (Infracambrian -? Cambrian)**

Named after Zaigun valley in the Central Alborz (Assereto, 1963).

The formation is characterized by a foliated slaty shale of wine-red colour, with alternations into purple, light-green, blue-green, speckled green and red, violet and black colours. Viewed from a distance the overall colour is wine-red to violet.

No fossils have been found in the Zaigun Formation; from its stratigraphic position it is considered to be Early Cambrian (?) or latest Precambrian (Stöcklin *et al.*, 1964; Stöcklin, 1971).

PALEOZOIC

There were no changes in sedimentation and tectonic character marking the beginning of this era in Iran, and almost everywhere a red arkosic sandstone (Lalun Sandstone) transitionally overlies the Infracambrian rocks (Nabavi, 1971). No orogenies affected Iran in Paleozoic times. The entire Paleozoic rock sequence, including the uppermost Precambrian and the Lower to Middle Triassic, indicates for the whole country rather uniform continental to epicontinental conditions and, except for gentle epeirogenic movements, great tectonic stability. These conditions suggest a platform character for the entire Iranian region during the Paleozoic era (Stöcklin, 1968).

(a) Lalun Sandstone (formerly called "Old Red Sandstone") (Lower Cambrian)

Named after the Lalun valley in the Central Alborz (Assereto, 1963).

The predominant rock is a uniform quartzitic to arkosic sandstone of medium grain and of purple to pink colour. A persistent member, which clearly marks the upper limit of the formation, is a white "top quartzite", about 60 m thick, separated in most sections from the underlying red sandstones by purple shale (Stöcklin *et al.*, 1964; Stöcklin, 1971).

Cruziana-like imprints discovered in the Lalun Sandstone were interpreted as footprints of trilobites of the *Redlichia* group, indicating Early to Middle Cambrian. This formation is directly overlain by Middle to Upper Cambrian fossiliferous beds of the Mila Formation (Stöcklin *et al.*, 1964; Stöcklin, 1971).

(b) Mila Formation (Cambrian to Ordovician)

(Named after Mila Kuh, a mountain in the eastern Alborz, west of Damghan).

The Lalun Sandstone is overlain by a varied sequence of dolomites, thin-bedded flaggy limestones, crystalline, partly glauconitic, limestones, marls, shales and somewhat sandy beds of the Mila Formation. The limestones contain the oldest determinable fauna known (trilobite), so far, in northern Iran. The formation as a whole ranges from Middle Cambrian to Early?-Middle Ordovician (Stöcklin *et al.*, 1964; Stöcklin, 1971).

(c) Lashkarak Formation (Ordovician)

Named after the Lashkarak pass in the Alam Kuh area, western Central Alborz (Gansser and Huber, 1962).

The formation is composed of sandstone, shale, dolomite, limestone and marl

containing trilobites, cystoids and brachiopods. The age of this formation is Early-Middle Ordovician (Stöcklin *et al.*, 1964; Stöcklin, 1971; Nabavi, 1971).

(d) **Geirud Formation** (Upper Devonian to Lower Carboniferous)

Named after the village of Geirud (Jeirud) in the upper Jajerud valley, Central Alborz (Assereto, 1963).

The formation consists of sandstones, conglomerates, limestone, a minor proportion of dark shales, and several phosphatic layers. Its age is Upper Devonian to Lower Carboniferous (Stöcklin *et al.*, 1964; Stöcklin, 1971; Nabavi, 1971).

(e) **Mobarak Limestone** (Lower Carboniferous)

Named after the village Mobarak in the Central Alborz east of Tehran (Assereto, 1963).

The formation is composed of dark fossiliferous limestone with subordinate black marl intercalations in the lower part. Numerous characteristic species of brachiopods, corals, and bryozoans indicate a Lower Carboniferous age for this formation.

(f) No definitely Upper Carboniferous rocks are yet known from Iran. The possibility of their occurrence in the Masuleh sheet area of Northwest Iran is discussed by Davies *et al.* (1972, pp. 36, 37).

(g) **Dorud Formation** (Lower Permian)

Named after the village of Dorud in the upper Jajerud valley, Central Alborz (Assereto, 1963).

The formation consists of red sandstone and shale with subordinate sandy and marly limestone. A grey, massive, sparry fusulinid limestone occurs in the middle part. The fossils of this formation suggest an Early Permian age.

(h) **Ruteh Limestone** (Late Permian)

Named after the village of Ruteh in the upper Jajerud valley, Central Alborz (Assereto, 1963).

The formation is composed of dark-grey, biogenic, medium-bedded to massive limestone overlying the red clastic beds of the Dorud Formation. It is attributed to early Late Permian ("Middle" Permian) (Stöcklin, 1971).

(i) **Nesen Formation** (Late Permian)

Named after the village of Nesen in the upper Nur valley, Central Alborz (Glaus, 1964).

The formation consists of alternating black marly shale and dark nodular foraminiferal limestone. The age is Late Permian.

MESOZOIC

Permian-Triassic transitional beds have been found only in sequences near Julfa, Naser, south of Amol, and Abadeh.

According to Stöcklin (1968, p. 1252), "What distinguishes the Alborz from Central Iran is not a greater, but a lesser, mobility. The Late Jurassic - Early Cretaceous movements did not cause angular unconformities in the Alborz, and were not accompanied by granite intrusions and metamorphism. The radiolarite-ophiolite associations (Coloured Melange) are unknown in the Alborz. Although there is remarkable Cretaceous volcanism in the central sector of the Alborz north flank, it is precisely on the entire north flank that no more trace of the Eocene "Green series" [Karaj Formation] is found and no Paleogene rocks whatsoever were deposited. This fact shows that an Early Alborz Range was present in Paleogene time; this later developed into a solid barrier between the Neogene basins of Central Iran on the south and the Aralo-Caspian depression on the north."

In southwestern Central Iran, in the Sanandaj-Sirjan zone, a large part of the Hamadan metamorphic rocks were metamorphosed in post-Aptian pre-Paleocene times (Berberian, 1972).

(a) **Elikah Formation** (Early to Middle Triassic)

Named after the village of Elikah in the upper Chalus valley region, Central Alborz (Glaus, 1964).

The lower part of the formation consists of platy to shaly limestone, partly marly, dolomitic, yellow to pinkish or greenish-grey (many beds crowded with worm tracks, rarely *calcaires vermiculés*), and some intercalations of edgewise conglomerate; the upper part comprises dolomite and dolomitic limestone. The age of the formation is Early to Middle Triassic (Stöcklin, 1971).

(b) **Shemshak Formation** (Early to Middle Jurassic)

Named after the village and coal mines of Shemshak, Central Alborz (Assereto, 1966).

As a result of the Alpine orogeny the sedimentational environment changed from a shallow-water to a lagoonal-fluviatile one, producing the Shemshak Formation (Nabavi, 1971). The formation is composed of an association of sandstones, siltstones, shales and claystones, variously alternating with thin coal seams. The age is Early to Middle Jurassic.

(c) **Dalichai Formation** (Middle Jurassic)

Named after Dalichai village and river in the eastern Central Alborz (Stratigraphic Names Committee of Iran, 1964).

The formation consists of richly ammonitiferous limestones and marly limestones, which in the Alborz Mountains are transitional between the plant-bearing sandstones and shales of the Shemshak Formation and the thick Lar Limestone. The age is Middle Jurassic (Stöcklin, 1971).

(d) **Lar Limestone (Late Jurassic)**

Named after the Lar valley in the Central Alborz (Assereto, 1963; Stratigraphic Names Committee of Iran, 1964).

The formation is composed of light-grey, compact, thin-bedded to massive limestone containing characteristic nodules and bands of white or violet chert. Age, Late Jurassic.

(e) **Tiz-Kuh Formation (Early Cretaceous)**

Named after Tiz-Kuh, a mountain southwest of Damavand, Central Alborz (Assereto, 1964).

The formation is composed of pinkish, medium-bedded, detrital limestone with intercalations of reddish polygenic conglomerates, overlain by fine-grained, white to pinkish, indistinctly bedded foraminiferal limestone (with abundant orbitolinas); on top, thick-bedded, white to pinkish limestone with rudists and big gastropods. Age, Lower Cretaceous.

In Central Iran, as distinct from other parts of the country, there is a strong angular unconformity at the base of the Cretaceous system, and sedimentation following the transgression began with a conglomerate-sandstone unit (Nabavi, 1971).

In the Alborz, after an erosional phase in Late Jurassic - Early Cretaceous, the sea transgressed upon an emergent land which had not undergone folding (Nabavi, 1971).

(f) **Unnamed Upper Cretaceous formation**

Assereto (1966) subdivided the unnamed Late Cretaceous formation into four members:

- Lowermost member, consisting of brown biomicritic limestone, locally with polygenic calcareous conglomerate at base, resting with angular unconformity on the Tiz-Kuh Formation. Age, Cenomanian - ? Early Turonian.
- Second member, consisting of light-grey, thin-bedded, micritic limestone, locally containing layers of intraformational breccia. Age, Late Turonian - Early Senonian.
- Third member, composed of brown, thick-bedded, organo-detrital limestone containing abundant chert nodules. A Middle Senonian age is inferred from the stratigraphic position.
- Fourth member, consisting of light-grey, thin-bedded marly limestone; this member is unconformably overlain by the Fajan Formation. Age, Late Senonian.

(g) **Marine Maastrichtian-Paleocene sediments** in the Chalus area have been described by Cartier (1971).

In the Chalus and Galanderud valleys these sediments form a continuous sequence up to the *Globorotalia trinidadensis* zone.

TERTIARY

In the Late Cretaceous regional emergence and a succeeding erosional phase affected the greater part of the country, and vigorous orogenic movements occurred, so that the Tertiary system unconformably overlies an erosion surface carved into older folded and deeply weathered rocks ranging from Precambrian to Late Cretaceous in age (Nabavi, 1971). The post-Aptian - pre-Paleocene, Laramide, orogeny was responsible for the metamorphism of part of the northwestern metamorphics of the Sanandaj-Sirjan zone (Sanandaj - Hamadan - Shahr Kord) (Berberian, 1972).

(a) **Fajan Formation** (Paleocene to Middle Eocene)

Named after the village of Fajan, east of Tehran (Stratigraphic Names Committee of Iran, 1964).

The formation consists of polygenic conglomerates, red sandstones and sandy marls, interbedded with agglomerates and andesitic flows. The Fajan Formation varies in age from Paleocene to Lutetian.

(b) **Ziarat Formation** (Paleocene to Eocene)

Named after the village of Ziarat in the Alborz foothills southeast of Tehran (Stratigraphic Names Committee of Iran, 1964).

The formation is composed of a reefal limestone with gypsiferous marl and gypsum in the lower part. Age, Paleocene to Middle Eocene.

(c) **Karaj Formation** (Eocene)

Named after the Karaj valley in the Central Alborz, west of Tehran (Dedual, 1967).

The formation consists of well bedded "green tuffs" and "tuffaceous shaly sediments". Dedual, following Lorenz (1964), distinguished the following members:

5. Kandavan Shales.
4. Upper Tuff Member – predominantly green tuffs with intercalations of tuffaceous shale, tuffaceous sandstone and calcareous shale.
3. Astara Shales – calcareous shale with subordinate beds of tuff and tuffaceous shale.
2. Middle Tuff Member – thick-bedded glass and ash tuffs, bluish green to light green, in the uppermost part with intercalations of calcareous shale.
1. Lower Shale Member – greyish-black calcareous and siliceous shale, partly tuffaceous with subordinate intercalations of green-grey glass and ash tuff; 20 m flow of augite porphyrite near base.

The age of the formation is Eocene.

Iowa and Hushmandzadeh (1971) stated that the volcanic rocks and pyroclastics of the Karaj Formation have undergone low-grade regional metamorphism deriving from deep burial. The metamorphic rocks of upper horizons represent a zeolite facies.

(d) Kond Formation (Late Eocene)

Named after the village of Kond Bala northeast of Tehran (Stratigraphic Names Committee of Iran, 1964).

The formation consists of grey sandstone and conglomerate overlain by gypsum and foetid marly limestone. Age, Late Eocene.

(e) Lower Red Formation (Oligocene)

Named by National Iranian Oil Company (1959).

This formation underlies the Qom Formation and consists of red and greenish silty shales and gypsum layers, volcanic flows and pyroclastics (Furrer and Soder, 1955). Age, Oligocene.

(f) Qom Formation (Middle-Late Oligocene to Early Miocene)

Named after the town of Qom in Central Iran (National Iranian Oil Co., 1959)

The name was introduced for a well defined unit of marine limestones and marls contrasting in lithology and colour with the red beds of the underlying Lower Red Formation and the overlying Upper Red Formation. The formation in Qom is divided into nine members. Age, Middle-Late Oligocene to Early Miocene.

(g) Upper Red Formation (Miocene - ? Pliocene)

National Iranian Oil Company (1959).

The formation overlies the Qom Formation and consists of thick gypsiferous and salt-bearing red marls, sandstones and conglomerates. A post-Burdigalian age for the Upper Red Formation is indicated by its position above the Qom Formation. Rieben (1935) adopted a Tortonian-Sarmatian age for this formation.

The Neogene sequence (Upper Red Formation) over the greater part of Iran is continental, resting on a regional angular unconformity surface inherited from the Alpine Orogeny. The most important tectonic episode in Iran in Cenozoic time was the Latest Alpine orogenic phase in the Pliocene, which determined the main outlines of the present physiographic features of the country (Nabavi, 1971).

QUATERNARY

A great part of the country is covered by Quaternary rocks comprising gravel fans, flood plains, salt playas, sand dunes, loess, freshwater deposits and volcanics.

(a) Hezardarreh Formation ("A" Alluvial Formation) (Pliocene)

Named after the Hezardarreh district, east of Tehran (Rieben, 1955, 1966).

This is the lowest alluvial formation of the northern Iranian plateau and is composed mainly of conglomerates with minor intercalations of sandstone and mudstone, particularly in the lower part. The characteristic features distinguishing this formation

from the similar but younger alluvial formations are:

- great thickness (1000-1200 m)
- regular bedding
- moderate size of pebbles (10-25 cm)
- pale-greyish colours
- advanced stage of alteration of the pebbles
- steep inclinations of beds (up to 50° and more)
- conformable and transitional contact with underlying Upper Red Formation,
- predominance of the green tuffs of the Karaj Formation as component pebbles, only 10% being derived from older formations.

Its stratigraphic position above the Upper Red Formation and regional correlation suggest Pliocene or Plio-Pleistocene, and in places possibly Late Miocene, age (Stöcklin, 1971; Rieben, 1955, 1966).

(b) **Kahrizak Formation** ("B" Alluvial Formation) (Quaternary)

Named from Kahrizak village, south of Tehran (Rieben, 1955, 1966).

This formation, overlying the Hezardarreh Formation of the northern Iranian plateau, is composed mainly of clayey loam, pale-brown loess-like material with patches of gravel and numerous elongated concretions or nodules analogous to freshwater limestone. The thickness in the type locality is about 10 m but exceeds 60 m in a few places. The age is estimated to be mid Quaternary (Rieben, 1955, 1966; Stöcklin, 1971).

This formation is distinguished from the older alluvium by

- its subhorizontal position
- poor consolidation and poor sorting
- generally heterogeneous "moraine"-like aspect given by the varying sizes (up to 100 m³) of the component pebbles and boulders,
- its generally darker colour than the Hezardarreh Formation.

(c) **Tehran Alluvium** ("C" Alluvial Formation) (Quaternary)

Named after Tehran, the capital of Iran (Rieben, 1955, 1966).

The next-overlying alluvial formation of the northern Iranian plateau comprises alluvial-fan deposits spreading from the foot of the Alborz mountains southwards and underlying all of the city and plains of Tehran. This alluvium is characterized by its distinct bedding and by a number of regularly intercalated red conglomerate crusts of laterite, representing stages of non-deposition. These are interbedded with layers of coarse sand, gravel, cobbles, and rare boulders, all derived from the green volcanic rocks of the Karaj Formation. The thickness of the formation varies from a few decimeters to normally not more than 50 m.

(d) **Recent Alluvium** ("D" Alluvial Bed) (Recent)

(Rieben, 1955, 1966).

This is the youngest gravel sheet, on which most of the city of Tehran is built.

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