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Late Triassic and Early Cretaceous sedimentary sequences of the northern Isfahan Province (Central Iran): stratigraphy and paleoenvironments

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Abstract

This research gives a general outline of the Upper Triassic and Lower Cretaceous sequences cropping out north of Isfahan, Central Iran. Upper Triassic Nayband Formation subdivided into the Gelkan, Bidestan, Howz-e-Sheikh, Howz-e Khan and Qadir members. Two biostromal levels are documented in the Bidestan and Howz-e-Khan members. Due to a suitable condition in Late Triassic time including light, oxygen and nutrient, fauna such as: corals, sponges, hydrozoas, bivalves, gastropods, brachiopods, echinoderms and *Dicroidium* were flourished in water and flora on land. The first appearance of *Heterastridium* spp. in level of the Bidestan Member is apparently the first occurrence of this taxon in Central Iran. Qadir Member has several key beds, one key bed with land flora *Clathropteris* spp., and three key beds with bivalve *Indopecten glabra*, dating as Rhaetian Stage. An angular unconformity can be traced between Rhaetian sediments and red conglomerates and sandstones of Lower Cretaceous Sequences in Isfahan area which encompasses all Jurassic rocks. This gap can be related to Cimmerian tectonic phase.

Keywords: Upper Triassic, Lower Cretaceous, Nayband Formation, Isfahan Province, Cimmerian.

Resumen

Este estudio provee de un esquema general de las secuencias del Triásico Superior y Cretáceo Inferior localizadas al norte de Isfahan, en el Centro de Irán. La formación Nayband del Triásico Superior está subdividida en los miembros Gelkan, Bidestan, Howz-e-Sheikh, Howz-e-Khan y Qadir. Dos niveles de biostroma están documentados en los miembros Bidestan y Howz-e-Khan. Debido a las condiciones favorables en el Triásico tardío que incluyeron luz, oxígeno y nutrientes, fauna como: corales, esponjas, hidrozoarios, bivalvos, gasterópodos, braquiópodos, equinodermos y *Dicroidium* prosperaron en el agua y la flora en tierra. La presencia de *Heterastridium* spp. en el nivel del Miembro Bidestan es aparentemente el primer registro de este taxón el Centro de Irán. El miembro Qadir tiene varios estratos índice, uno de ellos con flora terrestre *Clathropteris* spp., y tres estratos índice con el bivalvo *Indopecten glabra*, fechados como etapa Rhaetian. Una disconformidad angular se puede trazar entre los sedimentos Rhaetian, conglomerados rojos, y areniscas provenientes de Secuencias del Cretáceo inferior en el área de Isfahan que incluye a todas las rocas del Jurásico. Esta discontinuidad puede estar relacionada con la fase tectónica Cimmeriana.

Palabras clave: Triásico Superior, Cretáceo Inferior, Formación Nayband, Provincia de Isfahan, Cimmeriana.

1. Introduction

Upper Triassic and Lower Cretaceous rocks are spread widely in central and northern Iran. The major objective of the present study is the Upper Triassic (Norian to Rhaetian) sediments of the Nayband Formation exposed in three sections located in Dombi and Bagher Abad, north of Isfahan Province. In these localities, the Triassic deposits are overlain with a distinct angular unconformity by the Lower Cretaceous deposits, whereas Jurassic sediments are missing almost completely. The unit of conglomerate at the base of the Lower Cretaceous contains pebbles of carbonate and siliciclastic rocks without any sign of the Jurassic fossils.

The Nayband Formation contains abundant and taxonomically diverse marine invertebrate fauna. Since pioneering studies by Douglas (1929) who introduced the Nayband Formation and subdivided it into three members, sedimentology, biostratigraphy and palaeontology of this lithostratigraphical unit was outlined in numerous publications including Brönnimann *et al.* (1971), Kluyver *et al.* (1983), Fürsich *et al.* (2005), Seyed-Emami (1971, 2003), Zahedi (1976) and Hautmann (2001). Extensive studies on bivalve and gastropod molluscs from the Nayband Formation were published by Douglas 1929, Fallahi *et al.* (1983), Nützel and Senowbari-Daryan (1999), and Nützel *et al.* (2003). Valuable data on the Late Triassic paleoenvironment based on palaeoecological studies of bivalves were published by Repine (1996). Further data on the Triassic and Lower Cretaceous stratigraphy of Iran can be found in publications by Aghanabati (1998, 2006). Davoudzadeh and Schmid (1981) reported effects of the mid to late Cimmerian orogenic phase in Iran. Berberian and King (1981) studied on evolution of paleogeography in Iran. Golonka (2004, 2007) studied on evolution of plate tectonic of Eurasia margins and world in Mesozoic. Ghasemi and Talbot (2005) work on tectonic of Sannandaj- Sirjan Zone. (Fig. 1) shows Map of Geological Zones of Iran (knol. Google. Com).

2. Geological setting

Two studied sections (B and C) are situated about 35 km north-east of Isfahan, in the area located 10 km east of the Dizlu village, and 15 km north-east of Bagher Abad village (33° 4' N, 52° 2' E). The third section (A) is situated about 30 km west of Dizlu section, in the outskirts of the Dombi village (33° 3' 3" N, 51° 52' 20" E) (Fig. 2).

The Upper Triassic Nayband Formation in these sections can be subdivided into:

(1) the Gelkan Member of shales and sandstones; (2) the Bidestan Member of oolitic limestones, sandstones and reefal limestones with numerous algae, calcareous sponges and corals; (3) the Howz-e-Sheikh Member of shales and sandstones; (4) the Howz-e-Khan Member of reefal limestones with algae, calcareous sponges and corals.

The overlying sediments are referred informally to the Qadir Member (Fig. 3).

The Triassic lithostratigraphy applied to the studied sections was established by Brönnimann *et al.* (1971); Kluyver *et al.* (1983) and Fürsich *et al.* (2005), who gave a comprehensive outline of geology and facies of the Nayband Formation.

In the studied area, the Nayband Formation rests conformably on the Middle Triassic Shotori Dolomite. The Gelkan Member, up to 400 m thick, which is the lowermost lithostratigraphic unit within the Upper Triassic sequence, comprises intercalating shale and dark green sandstone beds with cross bedding and ripple marks. The succeeding Bidestan Member is about 11m thick and it starts with oolitic limestones containing abundant spherical hydrozoan *Heterastridium* spp. indicating the Norian age. Biostromal bioconstructions are also present. Sponges and corals are the main reef building organisms in the biostromes. *Heterastridium* spp. and bivalves are also relatively abundant. Corals such as: *Distichophyllia* cf. *Norica*, *Retiophyllia clathrata*, *Astraeomorpha crassisepta*, *Crassistella juvavica*. The Howz-e-Sheikh Member, up to 44 m thick consists mainly of light brown, barren, bedded sandstone. The overlying Howz-e-Khan Member, up to 15 m thick, starts with a thick limestone bed. It contains abundant reef building organisms, including: Sponges, Corals (*Distichophyllia* cf. *Norica*, *Oedalmia norica*, *Retiophyllia norica*, *Cuifia columnaris*, *Cuifia gigantella*, *Distichomeandra austriaca*, *Astraeomorpha confusa*, *Crassistella juvavica*) as well as reef dwellers represented by echinoderms, bivalves, brachiopods and gastropods (*Protorcula* sp., *Anulifera binodosa*, *Anulifera variabilis*, *Cryptaulax inaequelineata*, *Purpuroidea dilophosignata*). The uppermost Qadir Member comprises intercalating sandstones and marls total up to 200 m thick. It contains bivalve mollusc (*Indopecten glabra*) and flora (*Clathropteris* sp.) indicative of the Rhaetian Stage, which occurs up to the top of the unit. The Triassic sequence is overlain unconformably by the Lower Cretaceous of conglomerates and sandstones with some thin beds of coal (Fig. 4, c, d, f). Two horizons of terrestrial deposits can be recognized in the Lower Cretaceous in the north of Isfahan. They contain basal beds of conglomerate, but there is no evidence of sedimentation though the Jurassic in the area both *in situ* and from sedimentary clasts suggesting that regime of terrestrial exposition and erosion prevailed until beginning of the Cretaceous..

3. Discussion

The siliciclastic sedimentation prevailed during deposition of the Gelkan Member, which constitutes the basal unit of the Nayband Formation. Occurrence of wave ripple marks and bidirectional cross bedding in the sandstones suggest very shallow, peritidal to upper subtidal

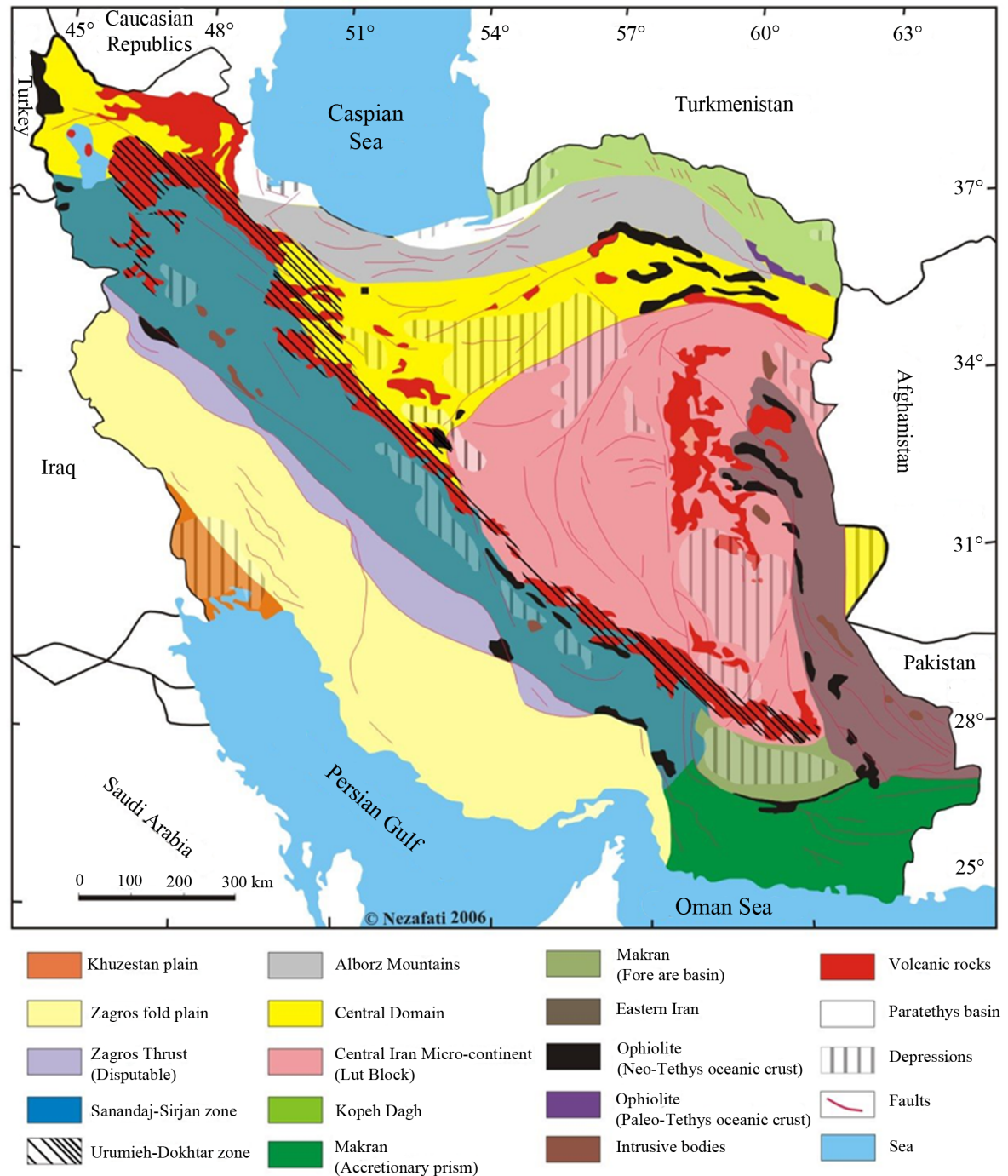


Figure 1. Map of Geological Zones of Iran (knol. Google. Com).

depositional environment. Carbonate sedimentation in the area started with deposition of oolitic limestone bed, which is the lowermost unit within the overlying Bidestan Member. Abundance of algae, corals and calcareous sponges, and a presence of the biostrom horizon suggest that the Bidestan

Member was formed in well oxygenized, shallow marine environment within euphotic zone rich in nutrients and periodically affected by seasonal storms. The taxonomic composition of the fauna and occurrence of *Heterastridium* spp. are characteristic of the Norian Stage. Siliciclastic

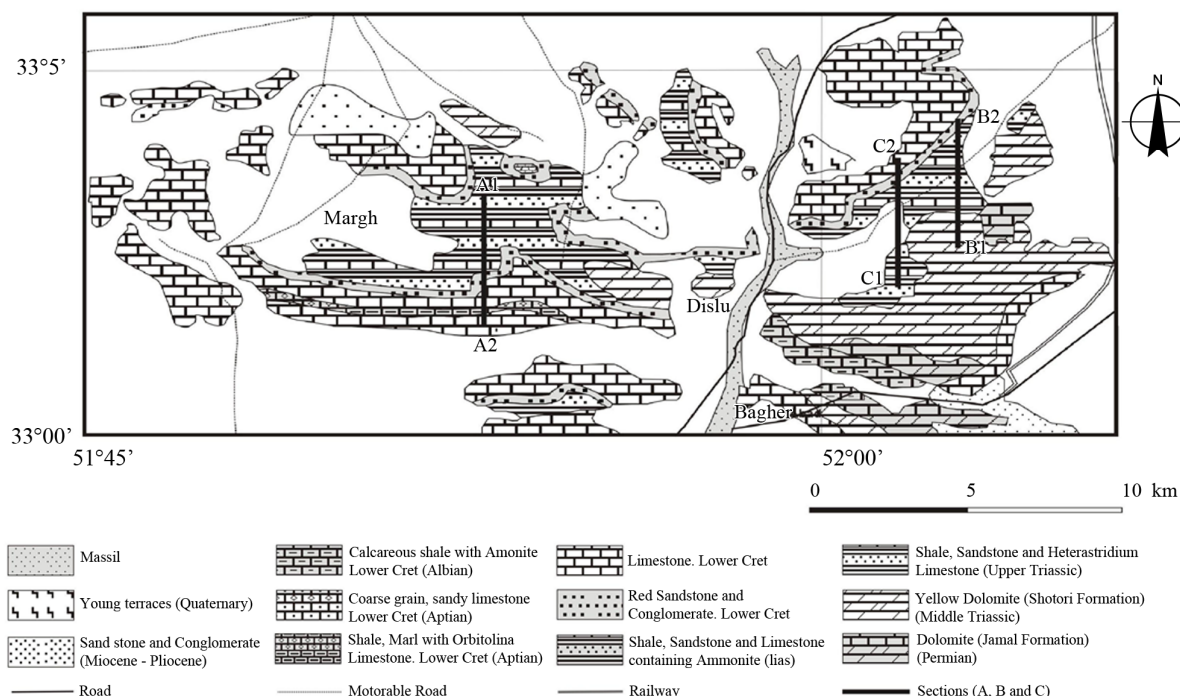


Figure 2. Studied area in North of Isfahan, Bagher Abad area (B1- B2 and C1- C2); Dombi area (A1- A2).

sedimentation was restored during formation of the succeeding Howz-e-Sheikh Member, however conditions favorable reef builders restored during formation of the Howz-e-Khan Member, which contains a second biostrom horizon up to 15 m thick in the lower part. Diversity of the faunal assemblage associated with these organic build-ups, including various sponges, corals, bivalves, gastropods, brachiopods and echinoderms, exceeds significantly faunal diversity recorded for the Bidestan Member. The hydrozoan *Heterastridium conglobatum* proliferates in this environment and it was grown up to 20 cm in diameter (Fig 5a-e), which is significantly larger than the specimens derived from the Bidestan Member where they do not exceed 4cm in diameter. It is likely that *Heterastridium* from the Bidestan Member represent a different species.

The upper part of the Qadir Member comprises intercalating sandstones and argillaceous limestones with a distinct fossiliferous horizon containing flora remains assigned to the *Clathropteris* sp. (Fig. 4a) and three shell beds formed by the bivalve *Indopecten glabra* (Fig. 5f). These beds are confined to the Rhaetian Stage.

During the Early Cretaceous, terrestrial conditions prevailed in the studied area. Conglomerate and sandstone beds contain scattered broken pieces of wood suggesting the Neocomian (Barremian).

3.1. Cimmerian tectonic phase

The Jurassic period was the important time in the

geological history of Central Iran, because it coincides with the accretion of several Iranian terranes to the southern margin of Euroasia. According to the recent plate tectonic reconstructions (Golonka, 2000, 2002; Golonka and Ford, 2000) Central Iran was within the system of the Cimmerian plates which rifted from the Gondwanan margin sometime in the Late Carboniferous-Permian time drifted northward, towards Euroasia during the Triassic. This collision resulted in a closure of the Palaeotethys Ocean and series of events related to the tectonic uplift, magmatism and metamorphism traditionally characterized in the Iranian geological literature as the Early Cimmerian orogeny (Aghanabati, 1998).

It is probable that the stratigraphic gap between Late Triassic to Early Cretaceous reflects a compressional regime and an uplift which coincides with the closure of the Palaeotethys Ocean. Mid Cimmerian orogeny in Central Iran was started in the Bathonian (Aghanabati, 1998). There is a big gap between Late Triassic and Lower Jurassic to Early Barremian documented in Central Iran. Wide spread unconformity at this level is reported from Qazvin and Taleghan (Annelles, 1975), as well as in northern Kerman Province and in Djam-e-Semnan Province (Central Iran). In Kopet-Dagh region is an angular unconformity between Kashafrud Formation and Late Triassic sediments (Aghanabati, 1998).

The base of the Early Cretaceous in Central Iran is defined by the characteristic unit of red conglomerate, which contains scattered fossil wood fragments and thin coal beds. Then deposition of the marine sediments commenced. The

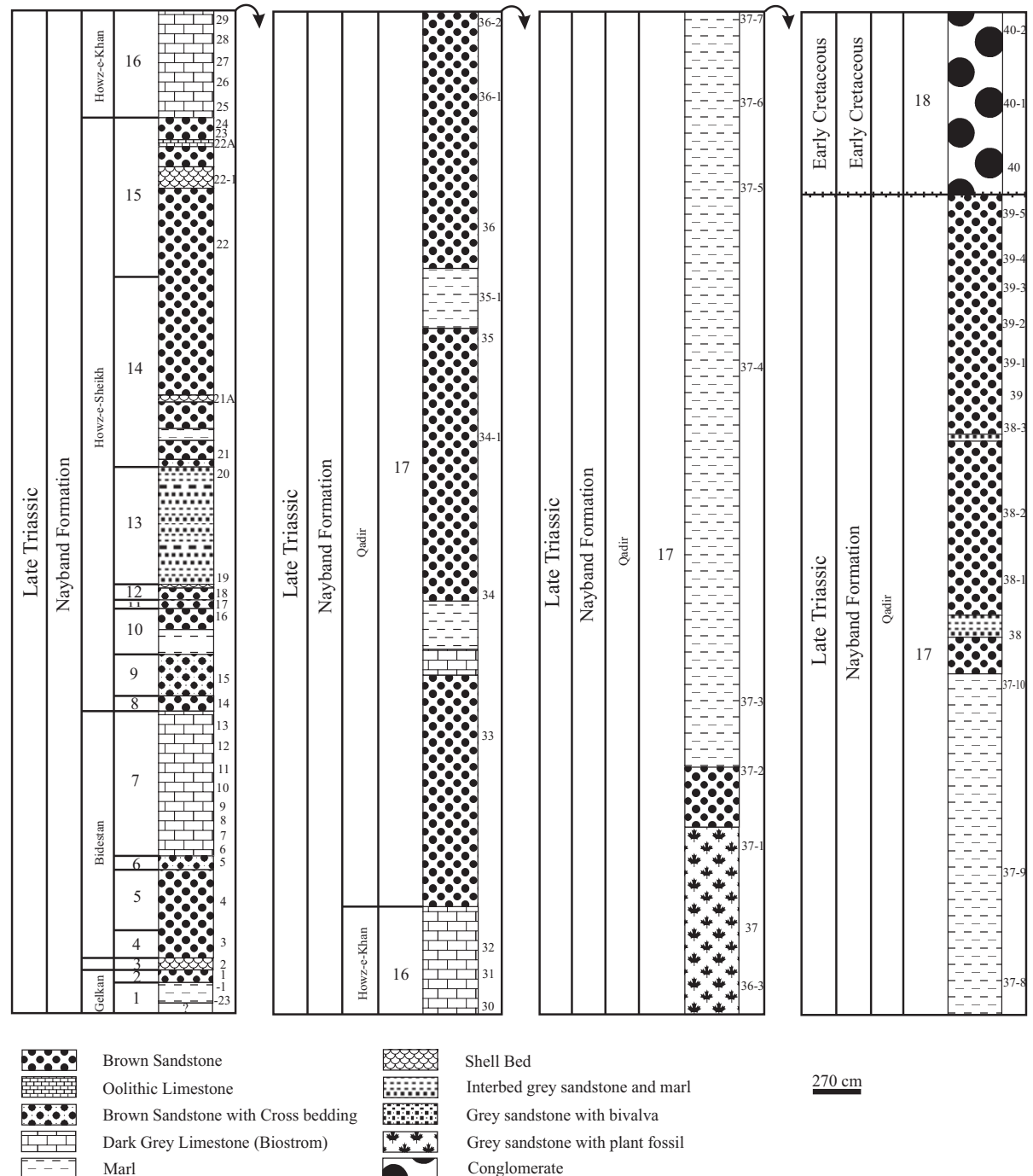


Figure 3. Stratigraphical column of Nayband Formation in Bagher Abad area, North of Isfahan.

conglomerate unit contains pebbles mostly of siliciclastic rocks (up to 80%), but also dolomites derived from the Shotori Formation (Fig. 4b). In the Soh area, 140 km north of Isfahan, basal Cretaceous conglomerates contain clasts derived from the Upper Triassic biostrom build-ups

(Kimiagari, 1995). Kolah Ghazi Granitoid located in 50 km South-East South of Isfahan. This igneous component is belonging to Sanandaj-Sirjan Zone. Granitoides created contact metamorphic in the shale and sandstone normally in the age of Rhaetian to Early Cretaceous time interval

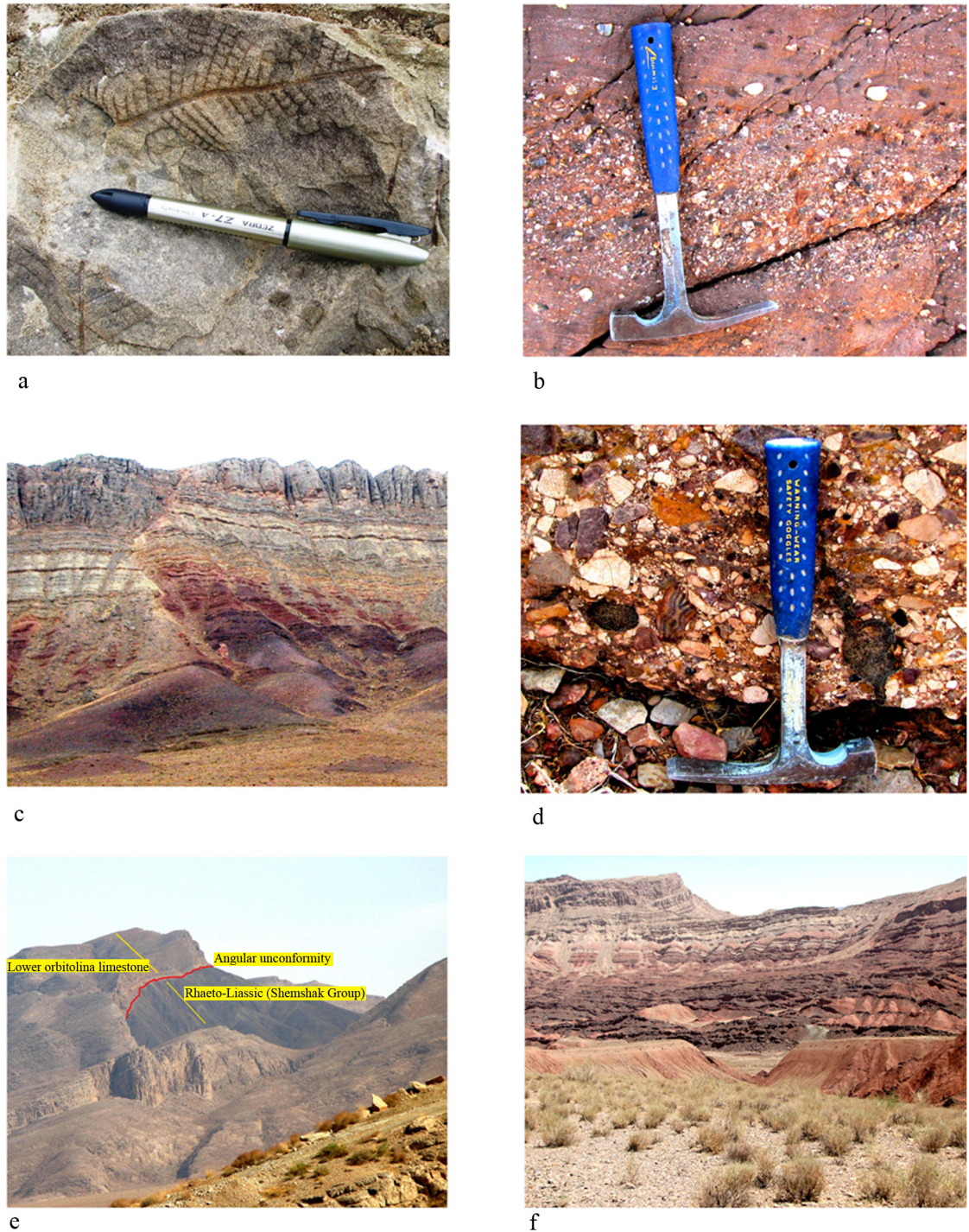


Figure 4. a) Plant key bed in Qadir Member, Nayband Formation in Bagher Abad area, North of Isfahan, b) Early Cretaceous conglomerate in Izadkhast area, south of Isfahan, c) Angular unconformity between Early Cretaceous and Rhaeto- Liassic sequences in Bagher Abad area, North of Isfahan, d) Pebbles of Early Cretaceous conglomerate in Dombi area, North of Isfahan, e) Angular unconformity between Early Cretaceous and Rhaeto-Liassic sequences in Kolah Ghazi, South-East South of Isfahan (after Yazdi *et al.*, 2009), f) Bidou Formation, North of Kerman.

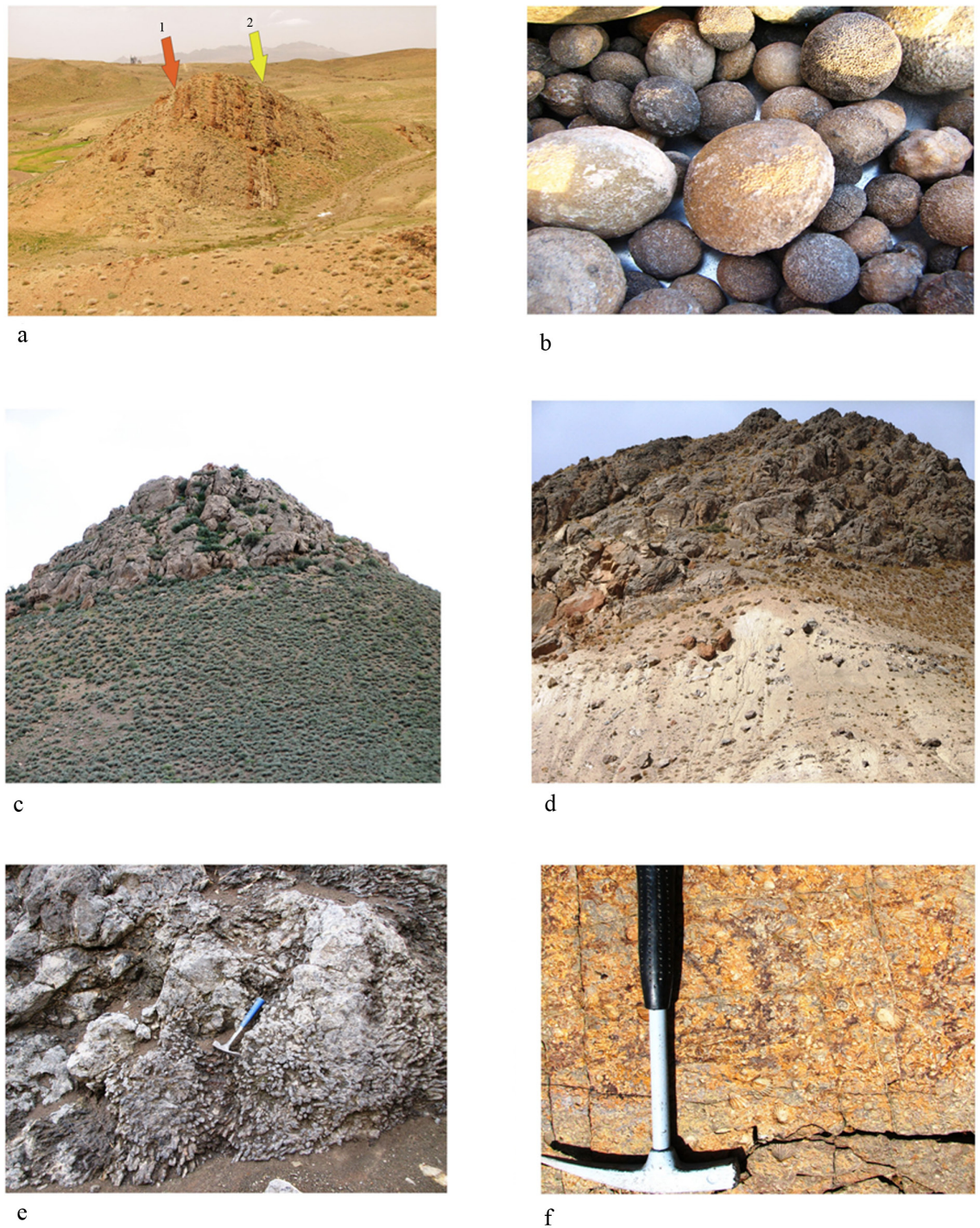


Figure 5. a) Biostrom 1, 2, Nayband Formation, Bagher Abad area, North of Isfahan, b) *Heterastridium* spp. in Howz-e-Khan Member, Nayband Formation, c) Grey reefal limestone in, Nayband Formation Delijan area, North of Isfahan, d) Grey reefal limestone in, Nayband Formation, Soh area, North of Isfahan, e) Colony of Corals in Howz-e-Khan Member, Nayband Formation, Bagher Abad area, North of Isfahan, f) Bivalve key bed in Qadir Member, Nayband Formation, Bagher Abad area, North of Isfahan.

(Tabatabaee, 1995) (Fig. 4e).

Unlike Central Iran and parts of the Alborz region, continuous marine sedimentation across the Jurassic – Cretaceous boundary is characteristic for the Zagros and Kopet Dag regions (Jamadi, 1998).

4. Conclusion

Faunal association of Bidestan and Howz-e-Khan Members characterized Norian- Rhaetian stages. Qadir Member contains *Clathropteris* sp. and *Indopecten glabra*. They indicated Rhaetian stage. Nayband formation is overlain unconformably by the Lower Cretaceous of conglomerates and sandstones. One big gap can be recognized in Jurassic time in Central Iran. Red conglomerate show transgression phenomena at the time of Early Cretaceous in Central Iran. Pebbles of conglomerate have several sources. There is no evidence of Jurassic fossils like Ammonite or microfossil in Early Cretaceous conglomerate. The lack of a part of Liassic, Dogger and Malm and Neocomian sediments related to Cimmerian phase.

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