



The Microbiostratigraphy and Depositional History of the Turonian–Santonian Surgah Formation at the Northern Flank of the Kuh-e Sepid Anticline, Lorestan Basin

Iraj Maghfouri Moghaddam

Department of Geology, Collage of sciences, Lorestan University

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Abstract

In this research, the microbiostratigraphy and depositional environmental implications related to the Surgah Formation at the northern flank of the Kuh-e Sepid anticline in the Lorestan Basin are discussed. A study of small planktonic foraminifera from the 101-m-thick Surgah Formation led to the identification of three Turonian–Santonian biozones: (1) *Helvetoglobotruncana helvetica*, (2) *Marginotruncana sigali*, and (3) *Dicarinella concavata*. The age of the Surgah Formation in the study area is determined as Turonian–Santonian. The Surgah Formation overlies the Sarvak Formation and underlies the Ilam Formation in the studied stratigraphic section. Based on an analysis of pelagic foraminiferal assemblages and microfacies features, seven different microfacies have been recognized. These can be grouped into three depositional environments: the inner, middle, and outer ramps.

Keywords: Turonian, Santonian, planktonic foraminifera, biostratigraphy, Lorestan Basin

1. Introduction

The main purpose of this research is to establish the biostratigraphic zonation and correlation with other universally accepted standard biozones and paleo-environmental frameworks based on planktonic foraminifera in the Surgah Formation at the Kuh-e Sepid anticline, Lorestan Basin, Iran (Fig. 1). The Surgah Formation is a part of the Bangestan Group in the Zagros Mountain, Southwest Iran (Motei 1993). It is only developed in the Lorestan Basin. In Khuzestan (Dezful Embayment) and Fars Basins, the Surgah Formation has not been deposited and the Ilam Formation overlies the Sarvak Formation disconformably (Fig. 2). The widespread Turonian unconformity resulted from both, a combination of localized uplift following initiation of the ophiolite obduction on the northeast Arabian plate margin, and possibly a global eustatic fall in sea level (Setudehnia 1978). Lithologically, the Surgah Formation consists of light and dark gray marl with interbeds of limestone. Its type section was measured at Tang-e Garab on the southwest flank of the Kuh-e Surgah, the northwest plunge of the Kabir Kuh, about 12 km southwest of the town of Ilam in the Lorestan Basin (James and Wynd 1965). The microfauna of the Surgah Formation were studied by Jalali (1971); Kalantary (1992) and Wynd (1965).

2. Material and Methods

For this research, 106 samples of hard rocks from the Surgah Formation in the selected stratigraphic section were collected and 106 thin sections were prepared and analyzed for their foraminifera and microfacies contents. All rock samples and thin sections are housed in the Department of Geology, Lorestan University. The composition of the thin sections was microscopically investigated in transmitted light. The taxonomic determination of the foraminifera is based on the foraminiferal classifications Bolli et al. (1987); Caron (1985) and Postuma (1971). Planktonic foraminifera are widely distributed in the Surgah Formation. Therefore, biostratigraphic zonation is based on this organism. Biozonations established for the Surgah Formation in this study are largely based on the biozonation of Premoli Silva and Verga (2004). Petrographic studies were carried out for microfacies analysis and paleoenvironmental reconstruction of the Surgah Formation. The definition of microfacies is based on depositional texture, grain size, grain composition, and fossil content. The classification of carbonate rocks followed the nomenclature of the Dunham (1962), Wilson (1975) and Flügel (2010) facies belts and sedimentary models were also used.

*Corresponding author.

E-mail address (es): Irajmms@yahoo.co.uk

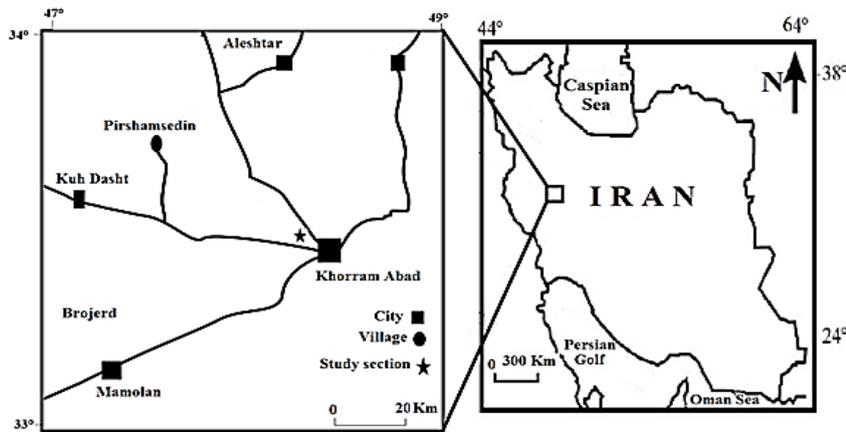


Fig. 1: Location map of study section in the Zagros region, southwest Iran.

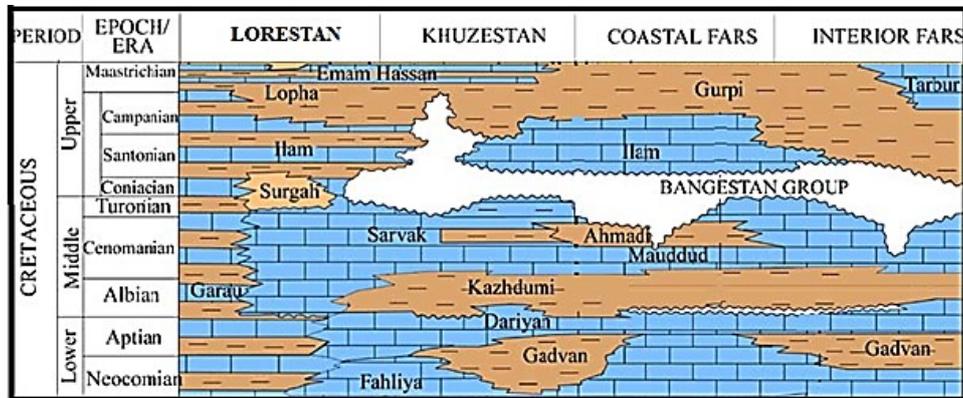


Fig. 2: Cretaceous lithostratigraphic units of the Zagros Fold–Thrust Belt (modified from Gulf Petrolink 1998).

3. Regional setting

The Zagros Mountain is at the southern part of an Alpine orogenic belt (Stocklin 1968). It extends from southeastern Turkey, through northern Syria and Iraq, to western and southern Iran (Alavi 2004). Post-tectonic and sedimentary events in Zagros resulted in the formation of several definable basins (Fig. 3a,b): Thrust Zone, Lorestan, Izeh, Dezful Embayment, Abadan Plain, Fars, and Bandar Abbas Hinterland (Sherkaty and Letouzey 2004). The Kuh-e Sepid anticline is located in Lorestan Zone. In the section study, the lower contact of the Surgah with the underlying Sarvak Formation and the upper contact with limestone of the Ilam Formation are disconformable (Fig. 4). In the field, the Surgah Formation is a low-weathering unit between two more resistant limestone units of the Sarvak and Ilam formations (Fig. 5). The thickness of the Surgah Formation is 101 m, and it contains dark gray marl and gray limestone (Fig. 6).

4. Biostratigraphy

Planktonic foraminifera are in abundance and diverse in most samples of the Sarvak, Surgah, and Ilam formations in the study section. Fourteen genera and 23

species of planktonic foraminifera were recognized (Plates 1, 2, and 3). The zonal scheme presented here consists of three zones on the basis of the stratigraphical distribution of planktonic foraminifera recognized in this section (Fig. 7). Biozone I occurs at the top of the Sarvak Formation and the lower part of the Surgah Formation. Biozone II is recorded in the middle part of the Surgah Formation. Biozone III appears at the top of the Surgah Formation and the lower part of the Ilam Formation.

4.1. *Helvetoglobotruncana helvetica* zone

Author: Sigal (1955)

Definition: Total range zone of the nominal taxon.

Characteristics: The dominant taxa belong to *Helvetoglobotruncana helvetica* (Bolli, 1945), *Clavhedbergella* sp., *Hedbergella* sp., *Hedbergella* cf. *simplex*, *Globigerinelloides* sp., *Whiteinella* sp., *Hedbergella* sp., *Hedbergella* cf. *monmouthensis*, and *Marginotruncana* sp.

The non-foraminifera assemblages include oligosteginid (*Calcisphaerula innominata*, *Pithonella ovalis*) and rudist debris.

Remarks: The first appearance of large, robust planktonic foraminifera, such as *Marginotruncana*, falls within this zone. In the Kuh-e Sepid, this zone spans 17m of light gray, medium to thick limestone at the top

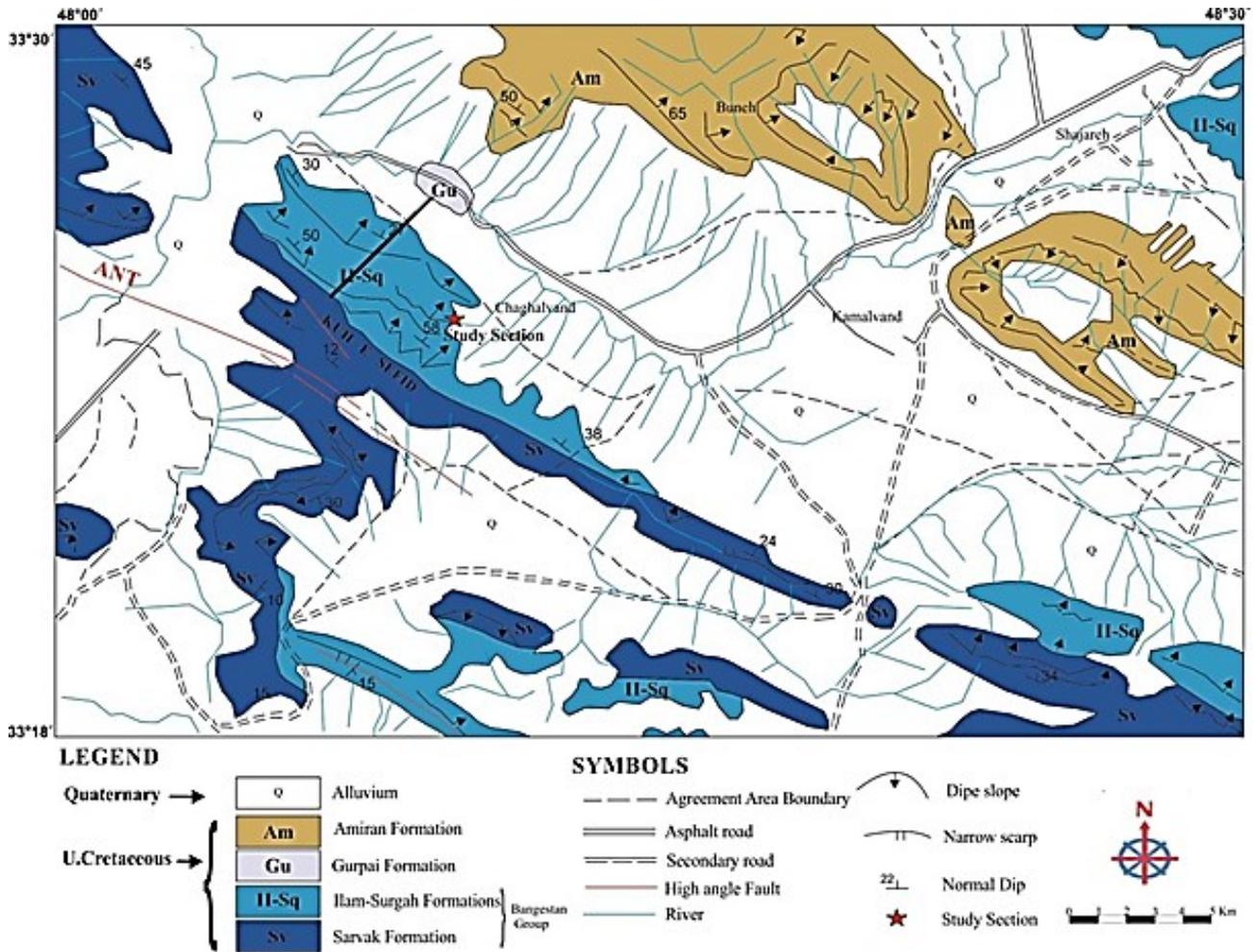


Fig.4: Simplified lithological map of Studied Section (modified after N. I. O. C).

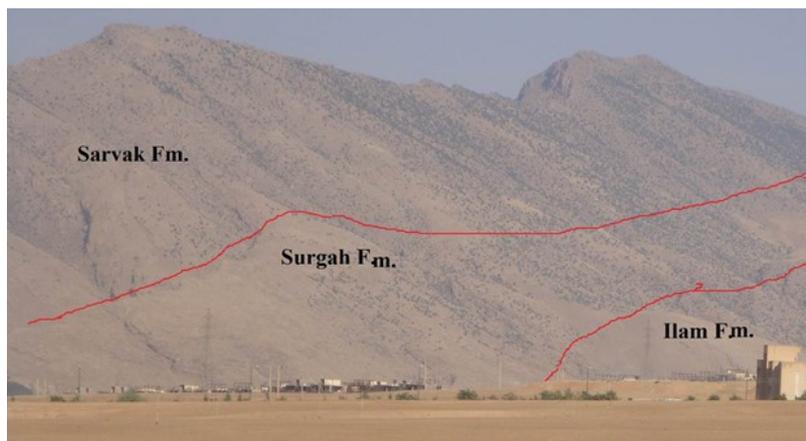


Fig.5: Outcrop photograph of the studied section at the north flank of Kuh-e Sephid anticline, Lorestan of the Zagros Basin, Iran.

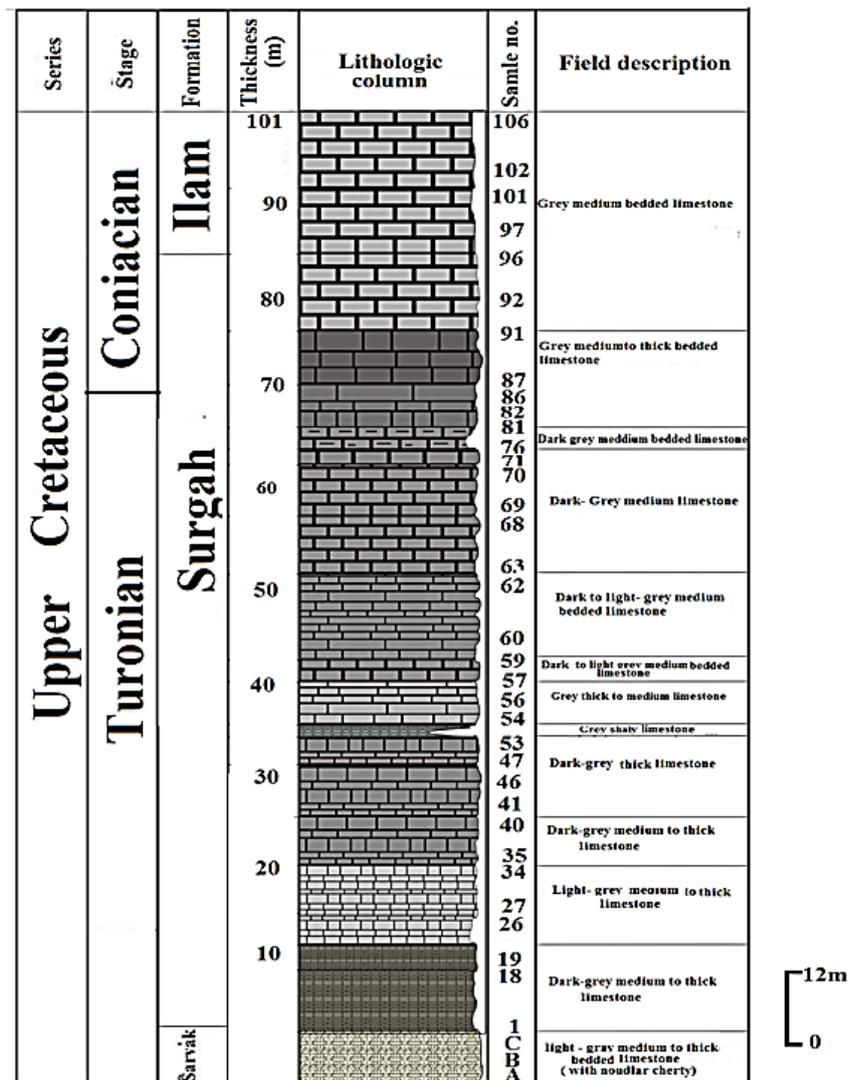


Fig.6: Lithostratigraphic column of the Surgah Formation in Kuh-e Sepid anticline, Lorestan of the Zagros Basin, Iran

5. Microfacies analysis

The petrographic studies led to the identification of seven microfacies (Fig. 7). The described microfacies are then attributed to specific depositional environments. The general environmental interpretations of the microfacies are discussed in the following paragraphs.

MF 1: Planktonic Foraminifera Mudstone (Fig. 8-A)
 This microfacies is mud-dominated. The main components of this microfacies are planktonic foraminifera, oligosteginids, and ostracoda shells. In some samples, laminations were observed. It is restricted to the lower part of the studied section. The high amounts of micrite and lack of sedimentary structures reflect a relatively low-turbulence environment suggesting that this microfacies was

deposited in calm, low-energy hydrodynamic and deep normal salinity water (Scholle et al. 1983). The absence of photo symbiont-bearing taxa suggests that this microfacies was deposited below the photic zone (Cosovic et al. 2004). It is interpreted to have been deposited below the Fair Weather Wave Base (FWWB) in a deep outer-ramp setting close to the basin edge and is comparable to the standard microfacies (SMF) 1 of Wilson (1975) and 1 Flügel (2010).

MF2: Planktonic foraminifera Wackstone (Fig. 8-B)
 This microfacies is dominated by Globotruncana, Hetrohelix, and bioclasts such as radiolarian, rudist debris, and ostracoda shell fragments. The matrix is fine-grained micrite.

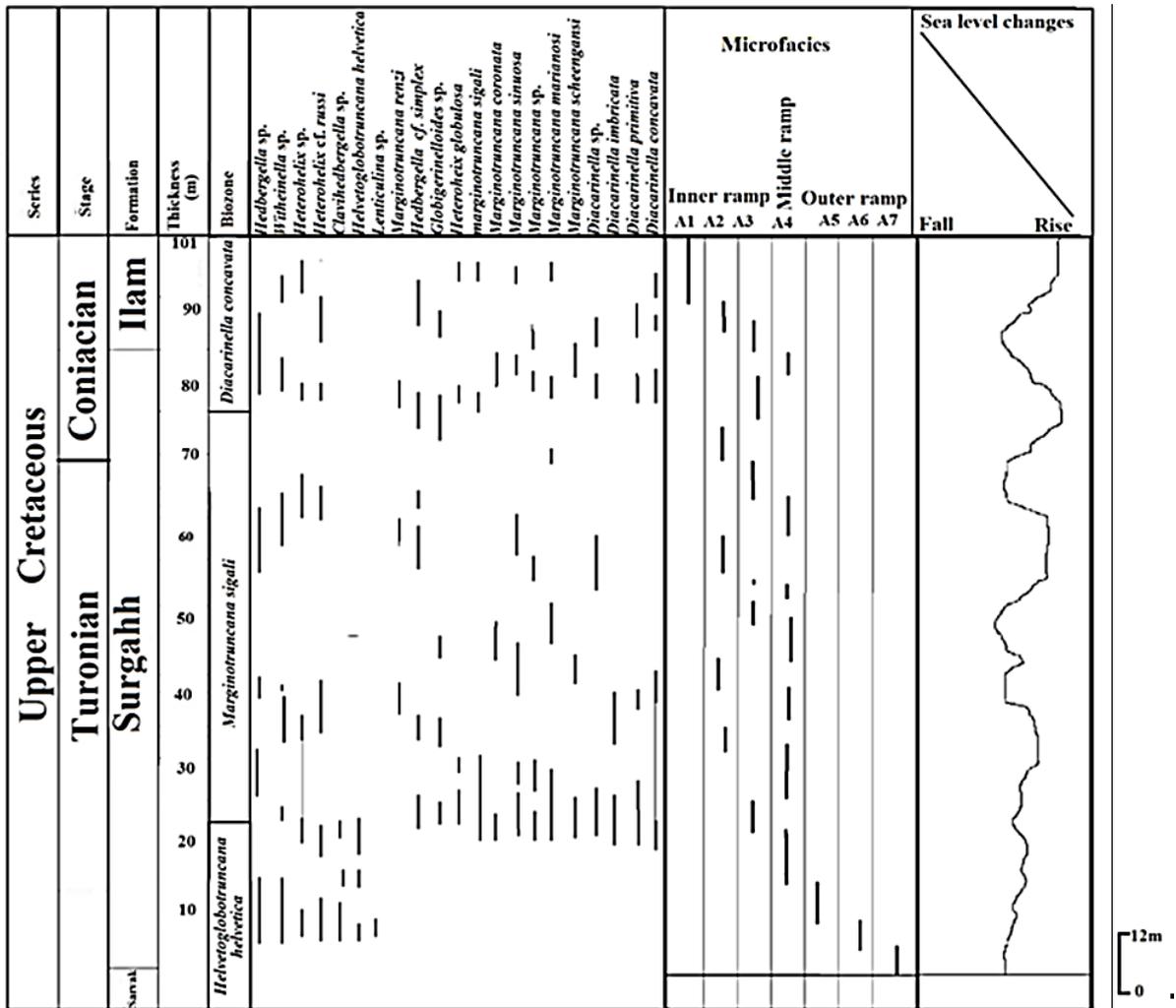


Fig. 7: Biostratigraphy col Vertical microfacies distribution umn and Vertical microfacies distribution of the Surgah Formation at the studied section, Lorestan of the Zagros Basin, Iran.

The predominance of mud-rich lithologies with planktonic foraminifera and the presence of pyritic material indicate deposition in a low-energy and below the FWFB, in a deep outer-ramp setting close to the basin edge, is comparable to SMF 2 of Wilson (1974) and 3 Flügel (2010). It is restricted to the lower part of the studied section.

MF 3: Bioturbated Mudstone (Fig. 8-C)

The most important feature of this facies biological process is chaos and dark brown spots. It was clear that mottled fabric is created. Microfacies 6 consists of dark micrite and planktonic foraminifera, and alternates with gray marls and argillaceous. It is interpreted to have been below the FWFB in a deep outer-ramp setting close to the basin edge (Wynd 1965), and is comparable to SMF 3 of Wilson (1975) and microfacies 1 and 3 Flügel(2010).

MF4: Oligosteginid Wackstone-Packstone (Fig. 8-D)

This microfacies is dominated by oligostegins and non-keeled planktonic foraminifera. The matrix is fine-grained micrite. The abundance of planktonic

opportunistic foraminifera e.g. heterohelicids and hedbergbellids indicate eutrophic low-oxygenated waters (Arthur et al. 1987). Oligostegenids and other calcispheres are abundant in the upper-slope and basinal carbonates, as well as in outer-ramp carbonates of low- and mid-latitudinal settings. The fossils can be used as bathymetric indicators of ramp margin and slope environments, and in the stratigraphic subdivision of the Late Jurassic to mid-Cretaceous Tethyan and subboreal pelagic carbonates (Flügel 2010).

The predominance of mud-rich lithologies with planktonic foraminifera indicates deposition in a low-energy and below FWFB in a deep outer-ramp setting close to the basin edge, and is comparable to SMF 1 and 2 of Wilson (1975) and 3 Flügel (2010).

MF 5: Intraclast Grainstone (Fig. 8-E)

This microfacies is composed of a variable proportion of rudist and echinid. The depositional texture is represented by grainstone. It consists of medium-bedded to thick-bedded, gray to brownish limestone beds. The sorting and grainy texture suggests a high-energy environment for these microfacies that have been deposited in a shoal environment, which separates the open marine from the more restricted marine environment and is comparable to SMF 6 and 7 of Wilson (1975) and 14 Flügel (2010). It is restricted to the lower part of the studied section.

MF 6: Intraclast/Bioclast Grainstone (Fig. 8-F)

This microfacies is predominantly composed of skeletal fragments, mud clast, and large intraclast. Biotic grain types include rudist and echinid. The grains are fine to coarse sand size and the sorting is good. The features of this facies indicate moderate- to high-energy shallow waters with much movement and reworking of booklists. Sediments are interpreted to have been deposited in sand shoal and are comparable to SMF 6 of Wilson (1975) and microfacies 14 Flügel (2010). It is restricted to the lower part of the studied section.

MF 7: Peloidal Packstone (Fig. 8- G)

Microfacies 6 is composed of small, grain-supported, sub-rounded, or sub-angular peloids forming irregularly distributed fine-grained packstone (pelmicrite), grainstone (pelsparite), and sometimes also packstone fabrics. The allochems are heavily influenced by microbial activity and micritization, so that most allochems are fully micrite, which suggests the effect of the photic zone in the environment. An inner- to mid-ramp (outer lagoon) facies that is comparable with microfacies 7 Wilson (1975) and 16 Flügel (2010) is suggested. The lagoon or inner ramp cannot be restricted as there is no evidence of evaporative precipitation or restricted hypersaline microfauna in this facies in the study area. The absence of supratidal-sabkha facies supports the interpretation that microfacies 7 were deposited in an outer part of the inner ramp.

6. Sedimentary Model

The Turonian–Santonian succession of the studied area indicates that sedimentation has taken place on the open marine carbonate, distally steepened ramp on the basis of the distribution of the biota, textures, and vertical facies relationships (Fig. 9). The carbonate ramp environments are separated into: (1) the inner ramp, (2) the middle ramp, and (3) the outer ramp.

The inner ramp facies have been deposited above the FWWB and divided into medium- to low-energy and high-energy conditions. Medium- to low-energy conditions consist of peloidal packstone and bioturbated mudstone.

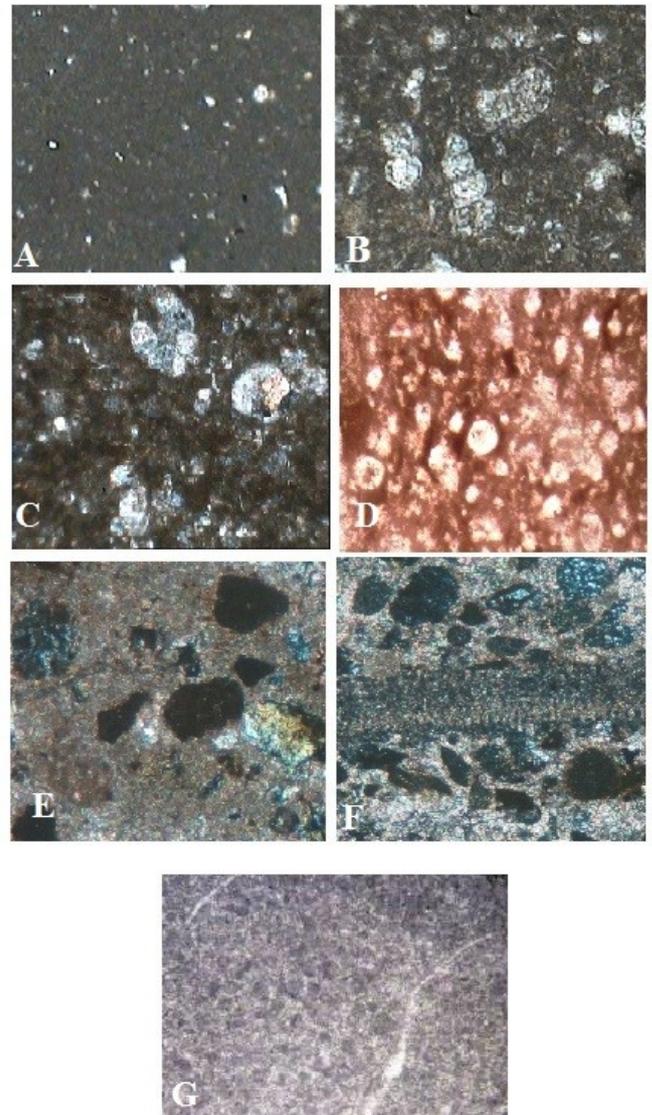


Fig. 8: Microfacies types of Surgah Formation, A- MF1: Planktonic foraminifera Mudstone, B-MF2: Planktonic foraminifera Wackstone, C- MF3: Bioturbated mudstone, D- MF4: Oligosteginid Wackstone to Packstone, E-MF5: Intraclast grainstone, F- MF6: Intraclast/ bioclast grainstone, G- MF7: Peloidal Packstone.

The bedding pattern differs from the decimeter to the meter scale. The small- to medium-scale bedding, normal to nodular, has a wavy to nodular appearance with a considerable amount of bioturbation. The facies are mostly related to the outer to middle part of the lagoon. The high-energy condition consists of intraclast/bioclast grainstone and intraclast/bioclast grainstone. It is organized in meter- to decimeter-scale beds, displaying planar lamination.

The thick and massive bedded facies end with rudist floatstone to rudstone, which can be very porous and may indicate warm conditions.

The middle ramp facies have been deposited between the FWWB and storm wave base, and contain oligosteginid Wackstone to Packstone organized in decimeter-scale beds. Locally, this facies is black and has a distinct smell, suggesting that organic matter is still preserved in the rocks.

The outer ramp facies have been deposited below the storm wave base and contains planktonic foraminifera's mudstone—Wackstone and Spiculite mudstone. The bedding pattern varies from the millimeter to decimeter scales. These mud-supported carbonate facies contain a considerable amount of echinoderm fragments and pyrite nodules, indicating rhythmic anoxic conditions.

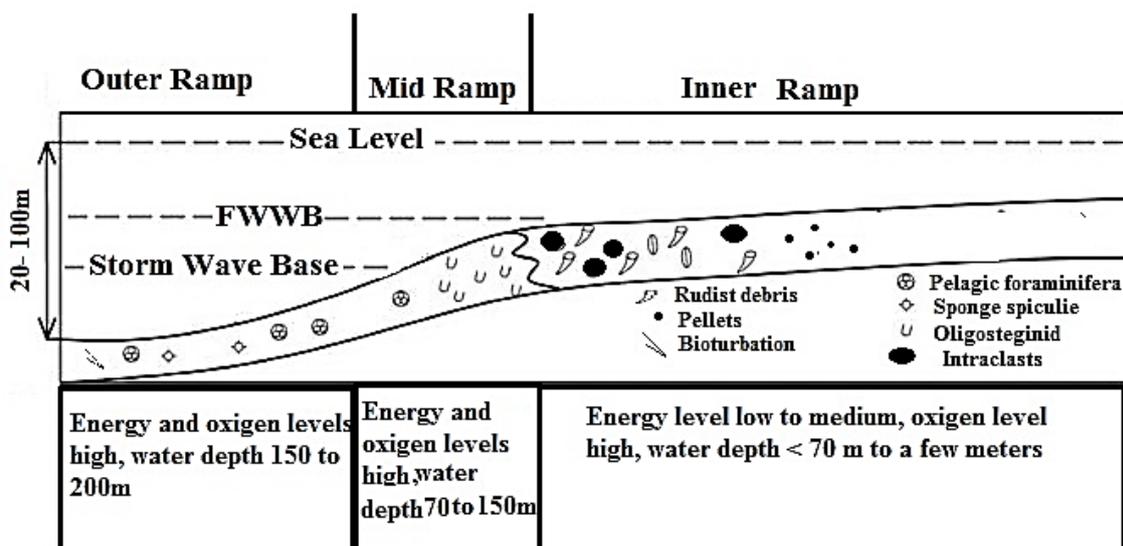


Fig. 9: Inferred depositional model of the Surgah Formation at the northern flank of Sepid kuh.

7. Conclusions

According to the distribution of small planktonic foraminiferal assemblage, the age of the Surgah Formation in the Kuh-e Sepid anticline is defined as Turonian–Santonian. Based mainly on the distribution of the foraminifera, three assemblage biozones are recognized. Assemblage 1 represents the Turonian age, Assemblage 2 the Coniacian age, and Assemblage 3 the Santonian age. Microfacies analysis led to the recognition of seven microfacies. Microfacies vary in lateral and vertical distribution, and show that carbonates were deposited on a distally steepened ramp.

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