International Journal of Basic and Applied Sciences, *1 (4) (2012) 380-389*
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Microfacies and Sedimentary Environments of Dalan Formation at Surmeh Mountain, Folded Zagros Zone, Southwestern Iran

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Abstract

The Permian carbonates- evaporates Dalan Formation is one of the most important gas reservoir in the Zagros Basin. The Zagros are located on the boundary between the Arabian and Eurasian lithosphere plates and are the Orogenic response to a collision between Eurasia and advancing Arabia during the Cenozoic. The study area is located at the eastern part of Surmeh Mountain, ~120 km south of Shiraz in the Folded Zagros Zone. Dalan Formation at Surmeh Mountain, with a thickness of 650 meters, is formed of three lithostratigraphic units. These units, from bottom to top, consist of Lower Dalan, Nar Member and Upper Dalan. The careful examination of thin sections led to the recognition of six microfacies which was performed on the basis of skeletal and non- skeletal grains and matrix (fenesteal dolomitic mudstone, layered anhydrite, lagoonal skeletal wackstone/ packstone, fine- grained ooid, peloid grainstone with lagoonal skeletal debris, medium- grained ooid grainstone with oomoldic porosity, open marine fossiliferous mudstone). Microscopic and macroscopic evidences show that Dalan Formation facies can be divided into four facies belts, on the basis of depositional features, specific of carbonate platforms of homoclinal ramp type. These belts include tidal flats, lagoons, shoal and basin environments.

Keywords: *Permian, Dalan Formation, Folded Zagros Zone, Surmeh Mountain.*

1 Introduction

Several thousand meters of siliciclastic, carbonate and evaporate sediments were deposited in the Zagros Basin in SW of Iran from Cambrian through Quaternary time [1, 2]. The Zagros are located on the boundary between the Arabian and Eurasian lithosphere plates and are the Orogenic response to a collision between Eurasia and advancing Arabia during the Cenozoic [3, 4, 5, 6, 7, 8, 9, 10, 11] (Fig. 1). Numerous northwest- southeast parallel folds were formed as a result of the collision and are now represented as spectacular, high amplitude anticlines and mountain peaks that rise more than 2500 meters above sea level.

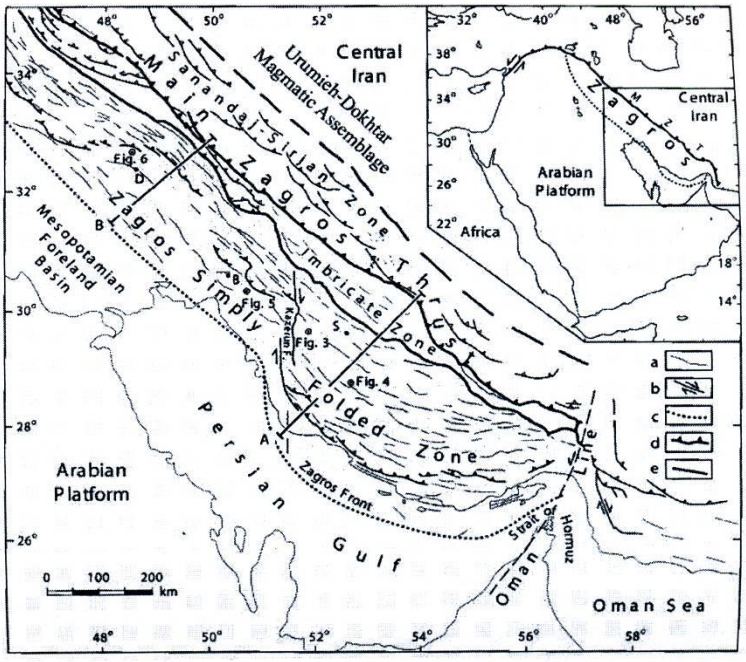


Fig. 1- Location of the Zagros Mountains in southwest of Iran, showing the five tectonically related parallel zones which give the overall structures of the Zagros Orogenic belt (after [11]).

In 1908, oil was discovered within one of the anticlines which led to several attempts to drill and prospect for oil. Now, the Zagros Fold and Thrust Belt region is known as a major petroleum source throughout the world.

This study focuses on Permian carbonates- evaporates assigned to Dalan Formation which are exposed in Surmeh Mountain in SW of Iran (Fig. 2). The first detailed study of Dalan Formation is attributed to Szabo and Kheradpir [12].The Dalan Formation is one of the most important gas reservoir in the Zagros Basin [13].

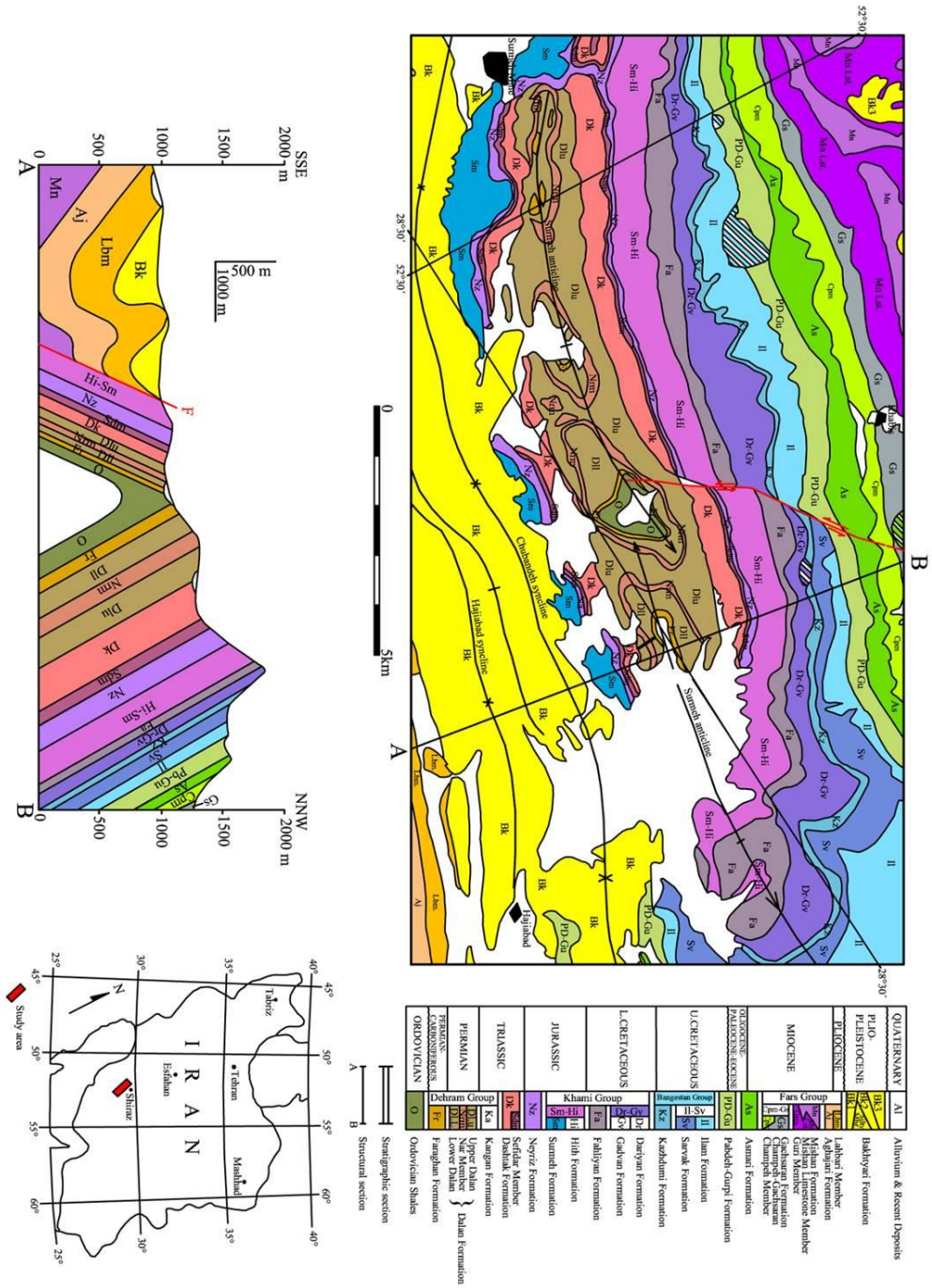


Fig. 2- Geological map and a cross section of the study area.

At its type section, which was measured underground at exploration well no.1 of Kuh-e-Siah (110 km SW of shiraz) between 2869- 3617 meters depths, the Dalan Formation consists of 748 meters of carbonate- evaporate lithology, which is divided from base to top, into three members: Lower Dalan Carbonate Member (informal), Nar Evaporate Member (formal), and Upper Dalan Carbonate Member (informal). The Dalan Formation overlies the Carboniferous Faraghan Formation conformably and is underlain by the Triassic Dashtak Formation disconformably.

2 Study Area and Methodology

The study area is located at the eastern part of Surmeh Mountain, ~120 km south of Shiraz in the Folded Zagros Zone. Geographically, the area is part of the Fars Province. Field work was concentrated at the southern flank of Surmeh anticline in the northwestern vicinity of Hajiabad village, about 10 km NW of Hangam city. A section was measured in detail along the northern and southern slopes of a mountain crossing the southern flank of an anticline at N: 28˚30′10″/ E: 52˚34′20″ (Figs. 2, 3, 4). The thickness of the exposed Dalan Formation is 650 meters. Samples were taken almost every three meters and sampling was based on facies variations. More than 125 thin sections were prepared and stained with Alizarin Red S. carbonate rocks were classified following Dunham [14]. Depositional processes were interpreted from the presence of skeletal and non- skeletal components, sedimentary structures, rock textures, and bed continuity [15, 16, 17, 18, 19]. Dalan Formation at Surmeh Mountain, with a thickness of 650 meters, is formed of three lithostratigraphic units (Fig. 5). These units, from bottom to top, consist of Lower Dalan (235 meters thick to massive bedded fossiliferous limestone changes upward to dolomitic limestone and dolomite), Nar Member (185 meters gypsum and dolomite alternations) and Upper Dalan (215 meters alternative layers of limestone and dolomite at lower part that change upward to limestone and dolomitic limestone).

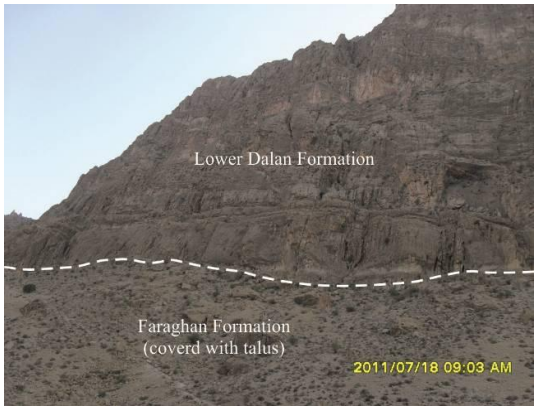


Fig. 3- Field photograph of Lower Dalan Member overlying Faraghan Formation (a south- ward view).



Fig. 4- Field photograph of Upper Dalan Member (a northwest view).

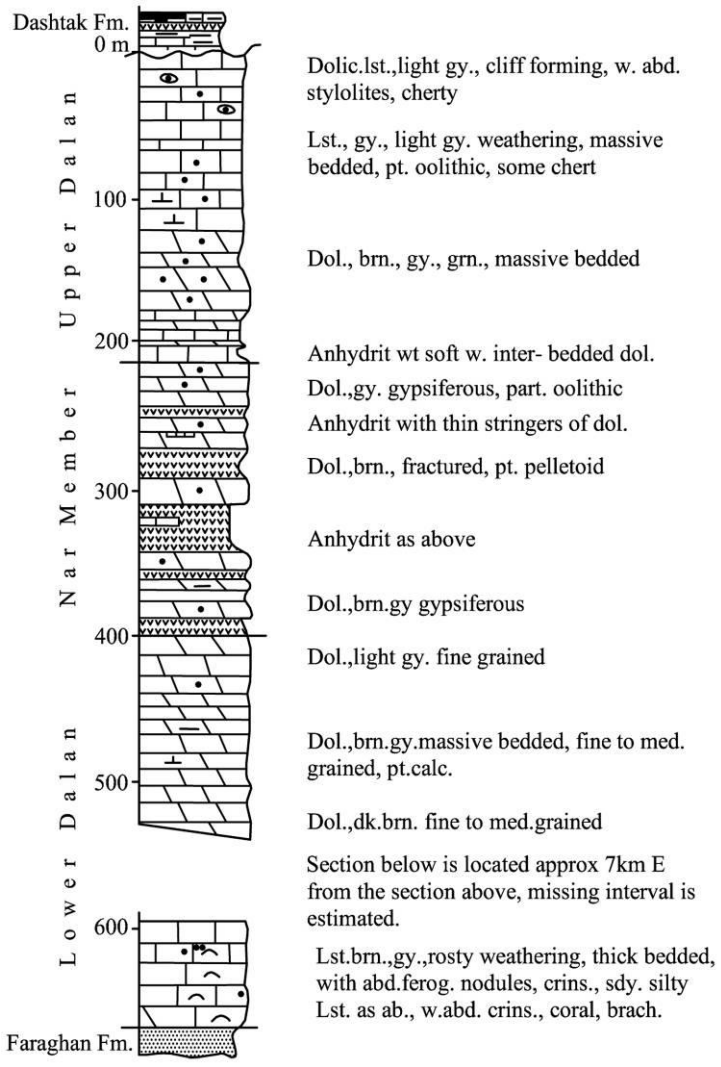


Fig. 5- Stratigraphic section (lithologic log) of the study area. Location of the section is shown in Fig. 2.

3 Microfacies Analysis

The careful examination of thin sections led to the recognition of six microfacies (Fig. 6) which was performed on the basis of skeletal and non- skeletal grains and matrix. These microfacies are as follows:

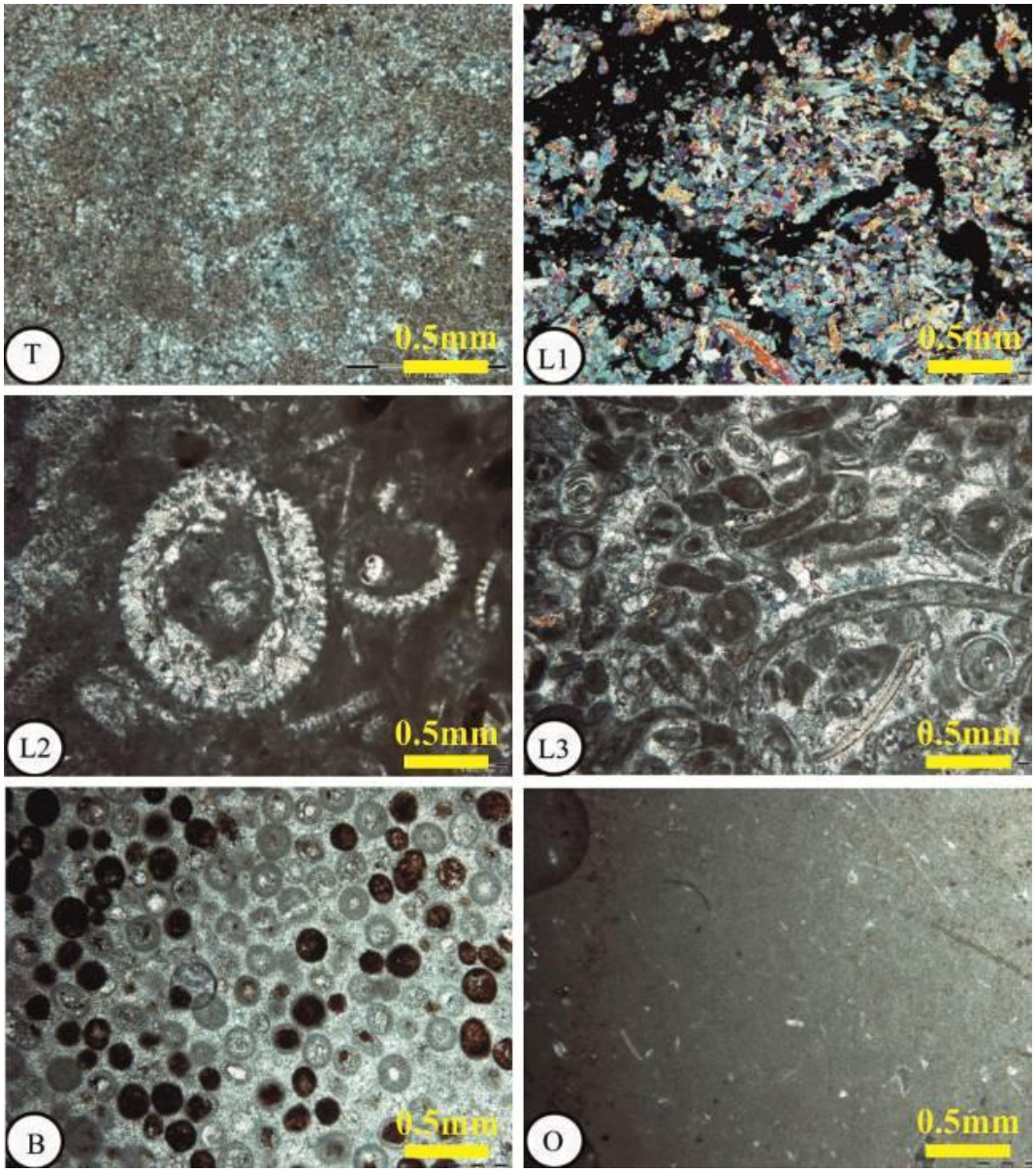


Fig. 6- General view of tidal flat, lagoon, shoal, and open marine microfacies, recognized in the Dalan Formation of the studied area.

3.1 Fenestral Dolomitic Mudstone (T)

Features such as fenestral fabric, evaporate molds, microbial filaments, mud cracks, and anhydrite nodules in a dolomicrite matrix are observed abundantly in this microfacies. This facies has intensively been influenced by diagenetic processes. Comparing with modern carbonate environments such as Persian Gulf [20], this facies has been deposited at upper parts of tidal flats in a warm and arid region.

3.2 Layered Anhydrite (L_1)

This microfacies is developed in Nar Member and may have deposited as gypsum layers in hyper saline lagoons. With passing of time and during the different stages of diagenesis the gypsum layers have been transformed into secondary anhydrite. Thick layers of anhydrite have been identified in the Nar Member of Persian Gulf and in the large parts of Arabian Platform [21]. This facies diminishes toward the north. For example, the thickness of the Nar Member in some oil wells in the Persian Gulf is 200 meters, while decreases to ~80 meters in Internal Zagros.

3.3 Lagoonal Skeletal Wackstone/ Packstone (L_2)

The components of this microfacies are mainly pelloids, benthic foraminifers, green algae, sponge fragments and gastropods. These components suggest a subtidal environment, most probably a restricted lagoon.

3.4 Fine- Grained Ooid, Peloid Grainstone with Lagoonal Skeletal Debris (L_3)

This microfacies is characterized with a high percentage of peloids and small ooids, plus skeletal fragments of lagoonal environment, which is indicative of a lagoonal shoal margin or leeward shoal. The main components are skeletal fragments, microbial filaments, and peloids. Most of the ooids (especially at upper Dalan Member) have been micritized and in some cases have been solved, resulting in moldic porosity. Peloids have probably been formed by breaking of lagoonal mudstones or micritization of aragonite ooids. Although in this facies, the relative preference from the viewpoint of abundance belong to peloids (> 50% of total allochems), but the origin of most peloids are the above- mentioned micritized aragonite ooids or broken lagoonal mudstones.

3.5 Medium- Grained Ooid Grainstone with Oomoldic Porosity (B)

This microfacies, as the main reservoir facies of Dalan Formation, have dominantly been formed of solved or replaced aragonite ooids (>70% of total allochems). Oolitic facies is well developed in different parts of Dalan Formation, especially at Upper Dalan Member. The appearance of this amount of aragonite ooids is mainly related to sea level changes in global scale (eustatic) and, to a lesser extent, to relative fall of sea level at the end of Permian [22, 23]. This facies has been formed in the middle parts of the barrier bars and in places that tidal currents and sea waves play important roles in forming ooid grains.

3.6 Open Marine Fossiliferous Mudstone (O)

One of the main features of this facies is the presence of about 8% sponge spicules and other skeletal fragments. Occasionally bioturbation is observed. This microfacies is lime- mud- dominated and suggests a deposition in a deeper environment of a carbonate platform.

4 Depositional Environments

Microscopic and macroscopic evidences show that Dalan Formation facies can be divided into four facies belts, specific of carbonate platforms of homoclinal ramp type (Fig. 7), and have been formed separate but relevant with each other, according to Walther Law.
These belts, as moving away from the coast, are:
1- Warm and arid tidal flats.
2- Restricted lagoons with relatively high evaporation.
3- Oolitic to skeletal barriers related to the middle part of a carbonate platform.
4- Open marine environments.

5 Conclusion

The Dalan Formation represents sedimentation on a carbonate ramp. Six microfacies are recognized within this carbonate platform section (fenestral dolomitic mudstone, layered anhydrite, lagoonal skeletal wackstone/ packstone, fine- grained ooid, peloid grainstone with lagoonal skeletal debris, medium-grained ooid grainstone with oomoldic porosity, open marine fossiliferous mudstone). These microfacies are grouped into four depositional environments representing tidal flat, shelf lagoon, shoal and open marine.

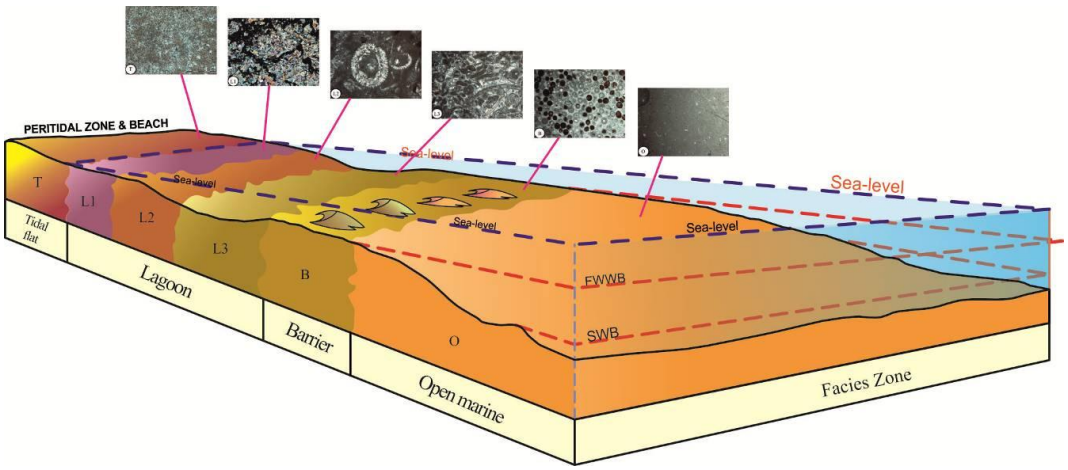


Fig. 7- Depositional model for the carbonate platform of the Dalan Formation at the study area.

Acknowledgements

The Authors appreciate Payam-e-Noor University of Shiraz for providing the financial support. Thanks also to Nahid Mehrvarzan for helping in the field and relevant drawings.

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