International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2014 Vol. 4 (1) January-April, pp. 68-84/Ghorbani et al.
Research Article

MICROFACIES, PETROFACIES AND SEDIMENTARY ENVIRONMENT OF THE BAHRAM FORMATION IN HUTK SECTION (NORTHERN KERMAN), IRAN

***Ghorbani M., Rostamnejad A. and Valiani Z.**

Department of Geology,

Hormozgan University, Iran

**Author for Correspondence*

ABSTRACT

Bahram Formation as carbonates and siliciclastic sequences of the Late Devonian of the Central Iran with a thickness of about 351 m in Hutk Section (North Kerman) is the matter of this research. This formation was rested on the red sandstones of the Padeha Formation and is overlain by Carboniferous carbonate deposits of the Hutk Formation. Bahram Formation is dominated by limestone, dolomite, sandstone and shale. Field studies and petrographic analysis of the Bahram Formation in this section helped us in the identification of 17 facies. This facies have been deposited in 5 facies belt including shoreface, tidal flat, lagoon, shoal and open marine. Based on the lateral and vertical changes of facies (microfacies and petrofacies), the lack of barrier reefs, lack of sliding, slumping and calciturbidite and gradual change of facies, Bahram Formation have been deposited in a mixed carbonate-siliciclastic homoclinal ramp.

Keywords: *Bahram Formation, Hutk Section, Mixed Carbonate-Siliciclastic Ramp*

INTRODUCTION

Middle to Late Devonian Bahram Formation is composed of carbonates and siliciclastic sequences in the Central Iran. Pioneer works on this formation have been done by Ruttner *et al.,* (1965), Flügel and Ruttner (1962), Stocklin (1972), Stocklin and Setudehnia (1991), Dastanpour and Aftabi (2002), Morzadec *et al.,* (2002), Webster *et al.,* (2003), Wendt *et al.,* (2002; 2005), and Gholamalian and Kebriaei (2008). Review of the previous studies revealed that integrated studies of facies and paleoenvironmental reconstruction have not been done till now. So, the main objectives of this research are the identification of facies and paleoenvironmental reconstruction of the Bahram Formation. In order to gain the goals, a surface section of the Bahram Formation has been selected. This section is located in the Hutk area, North of Kerman in the southeastern Central Iran (56˚ 56' 42″-57˚ E and 30˚ 34' 28″- 36˚ N) (Figure1).

Stratigraphy

Bahram Formation lithologically consists of fossiliferous limestone, dolomitic limestone, sandstone and shale. This formation is a part of the Ozbak-Kuh Group and its type section is located in the south of Ozbak-Kuh. This formation in the section (Ozbak-Kuh) has been divided into two parts, Bahram 1 with the age of Givetian to Frasnian and Bahram 2 with the age of Frasnian (Ruttner *et al.,* (1965). these two cannot be differentiated in other sections (Figure 2). The thickness of the formation in the Hutk section is about 351 m (Figure 3). In the studied section, Bahram Formation continuously rests on the red sandstone of the Padeha Formation (Figures. 2, 3 and 4 A, B and C) and is overlain by the Hutk Formation (equivalent to Shishtu-2 Member) (Wendt *et al.,* 2002; Figures. 2, 3 and 4 D, E, and F). The upper boundary between Bahram and Hutk Formations is disconformable.

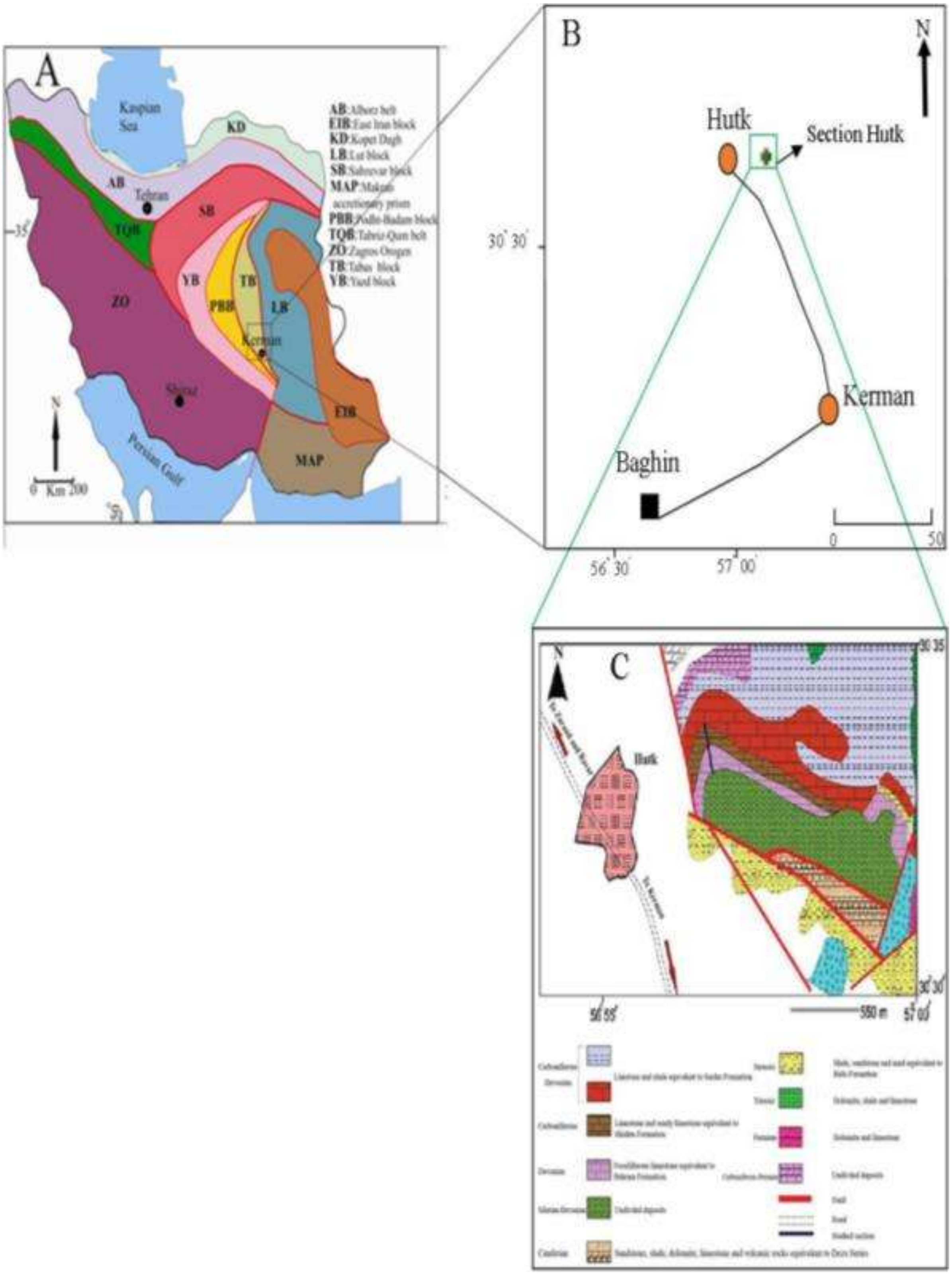


Figure 1: A – Location map of the studied area in the Central Iran (After Alavi 1991). B – Ways to access the studied area. C – Geological map the studied area (After Gholamalian 2006)

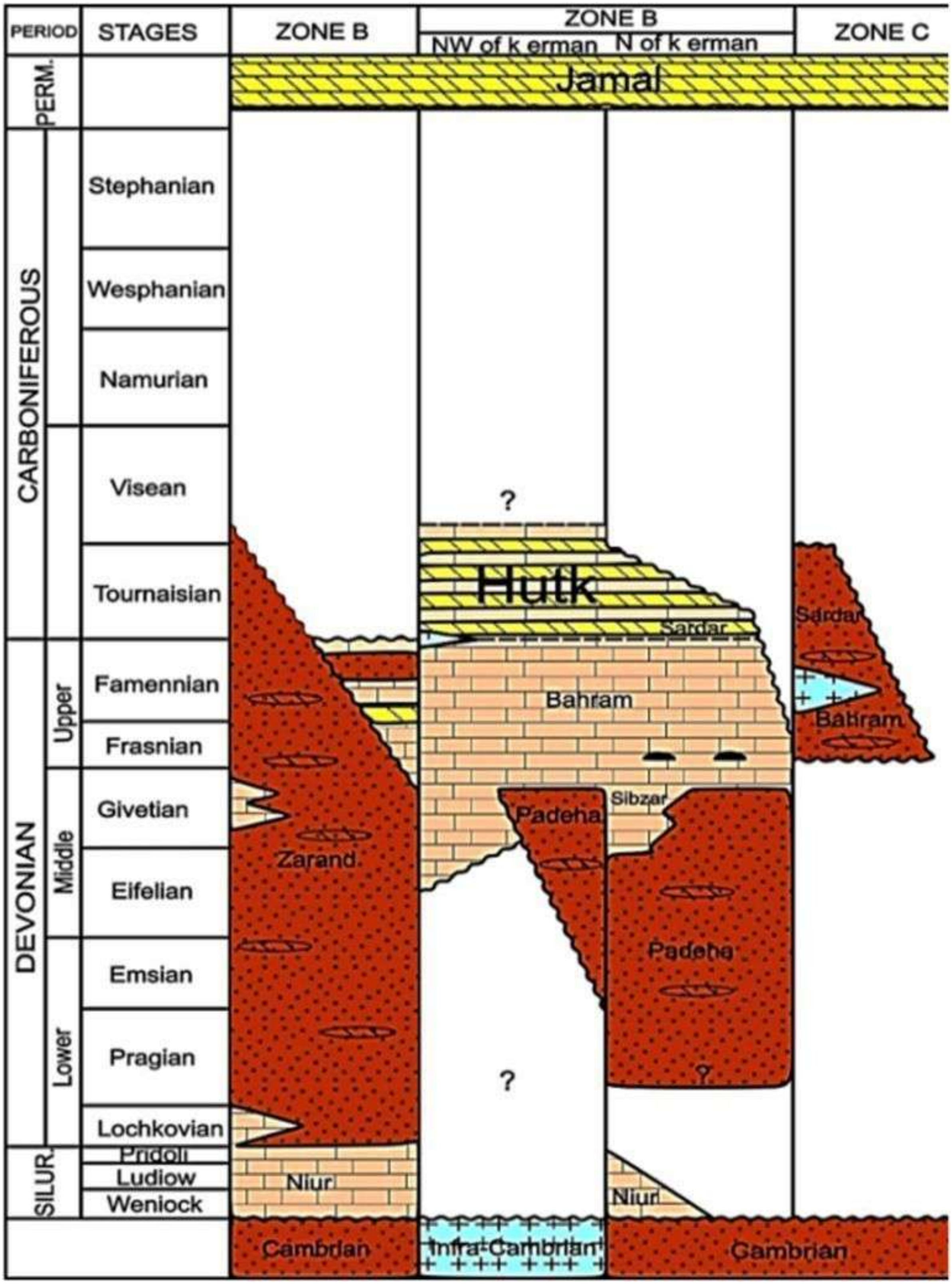


Figure 2: Lithostratigraphy of Silurian to Permian Formations in NW-N of Kerman (After Wendt *et al.*, 2002)

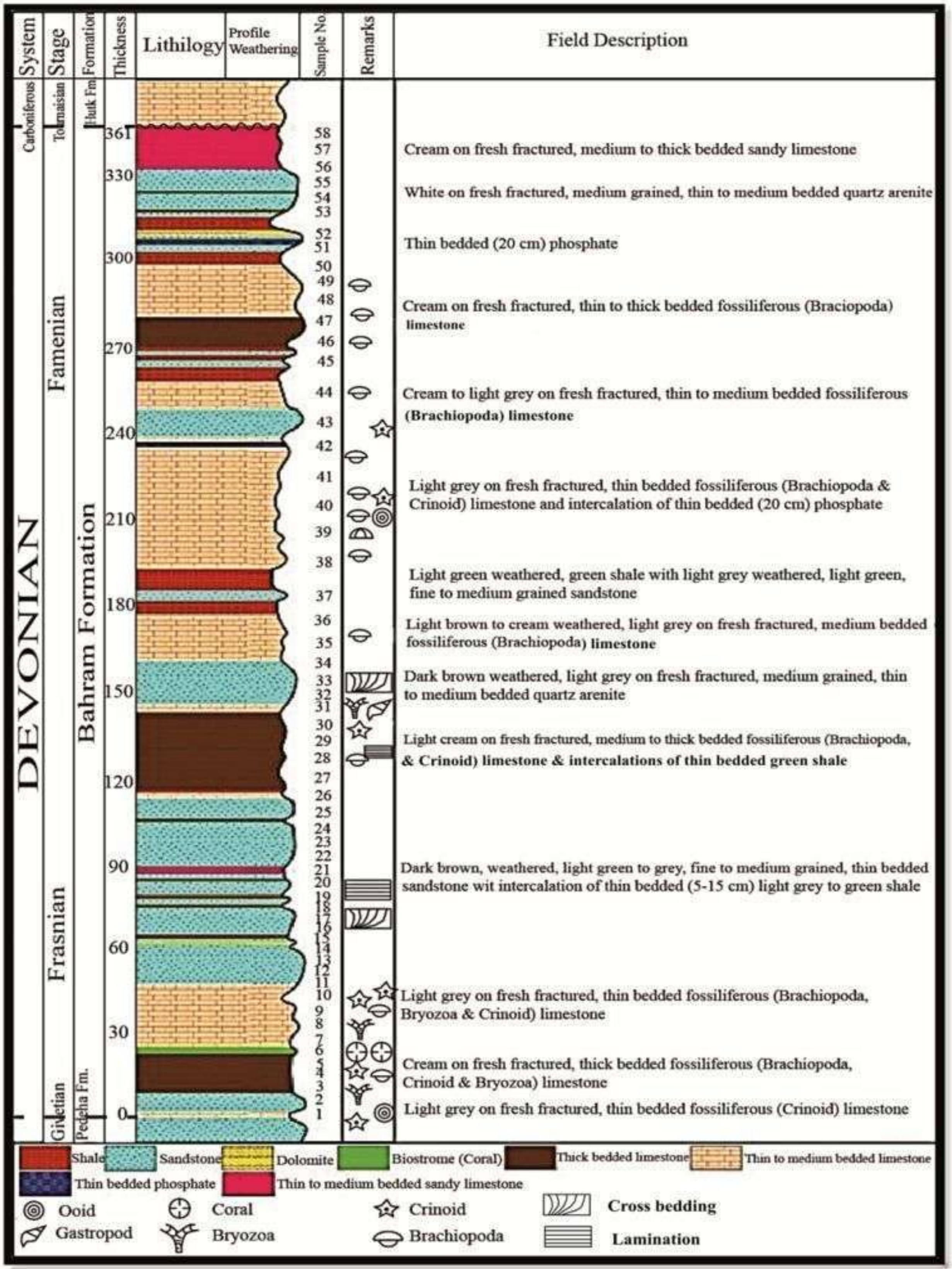


Figure 3: Stratigraphic column of the Bahram Formation in the Hutk Section

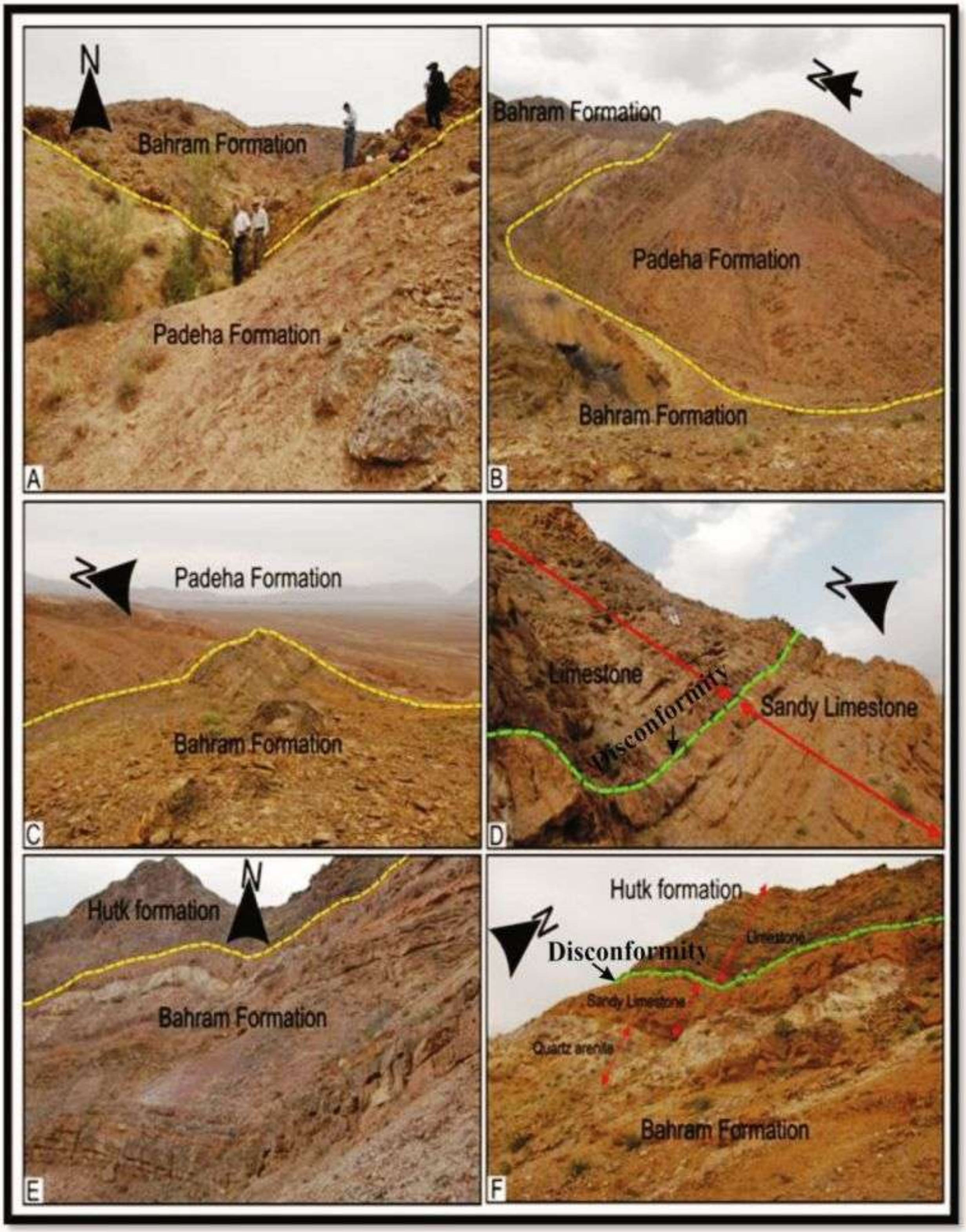


Figure 4: A- Bahram Formation covers the Padeha Formation; B and C- Padeha Formation located in the anticline core; D, E and F- Sandy limestone of the Bahram Formation is disconformably overlain by Carboniferous dark limestone of the Hutk Formation.

MATERIALS AND METHODS

This study is based on the field and microscopic investigations of an outcrop of the Bahram Formation in the Hutk section. Lithology, color, geometry, sedimentary structures, facies association, fossil contents and fabrics (grain size) have been recorded and documented with simultaneous photography. 58 samples have been collected for thin section preparation. Thin sections have been studied by polarized microscope. In petrographic studies, lithology, fossil contents, fabrics and facies have been described. Methods of Pettijohn *et al.,* (1987) and Dunham (1962) have been used to classify sandstones and limestones. Facies belts have been determined based on the Flügel (2010) standard facies belt. Finally schematic 3D depositional model have been suggested for deposits of the Bahram Formation in the Hutk section.

RESULT AND DISCUSSION

Facies

Based on field studies and petrographic investigations of thin-sections. 17 facies have been identified in the Bahram Formation of the studied area. The facies can be divided into two main categories including siliciclastics and carbonates. They have been deposited in different facies belt including foreshore and mud flat (siliciclastics facies) and tidal flat, lagoon, shoal and open marine (carbonate facies) (Figure 12 and 13). Siliciclastic and carbonate facies have been described here respectively.

Siliciclastic Facies *(A)*

1- Sandstone facies

Sandstones are mainly composed of cream to brown medium to thick bedded layers with different sedimentary structures including trough cross bedding (Figure 5B) and parallel lamination (Figure 5C). Trace fossil of skolithos are also present. Sandstones are mainly quartz arenite and sublitharenite.

1-1 Quartz Arenite (A1)

This facies is composed of light brown to white, thin to medium bedded, fine to medium grained sandstone (Figure 6A). Parallel lamination and trough cross bedding (Figure 5B) are common. The main component of this facies is well sorted, sub-rounded quartz grains with the amount of about 95%. Feldspar and rock fragments totally are less than 5%. This facies shows medium to well textural maturity (Figure 6 A, B and C). Grain contacts are in the form of concavo-convex as a result of compaction.

1-2 Sublitharenite (A2)

This facies consists of brown thin to medium bedded, fine to medium grained sandstone. It mainly consists of quartz grains (>80%). Chert with sedimentary rock fragments (dolomite and muscovite) (20%) are subordinate components. Matrix (> 5%) are also present (Figure 6 D, E and F). grains are sub-rounded to rounded. As a point of view of textural maturity, facies is submature to mature.

2-Shale (A3)

The A3 facies is grey, purple and green; thin to medium bedded shale (Figure 5 D and E) with intercalation of sandstone and rarely limestone. This facies is present in the lower and upper part of the Bahram Formation. Thickness of shale layers are up to 2 meters. Mud cracks are the obvious sedimentary structure of this facies (Figure 5 F).

Interpretation

Textural and mineralogical maturity are the result of high transportation. Trough cross bedding and parallel lamination demonstrate that sandstones have been deposited in high energy environment in foreshore and shoreface. Ichnofacies of skolithos confirm this result, because it is usually associated with high-energy environments close to the shoreline (Flügel 1982; Desjardins *et al.,* 2010). Modern example of that is Golveston Island in Mexico (Elliott 1986). Intercalation of shale with sandstones of shoreface and presence of mud cracks demonstrates that shale has been deposited in the mud flats.

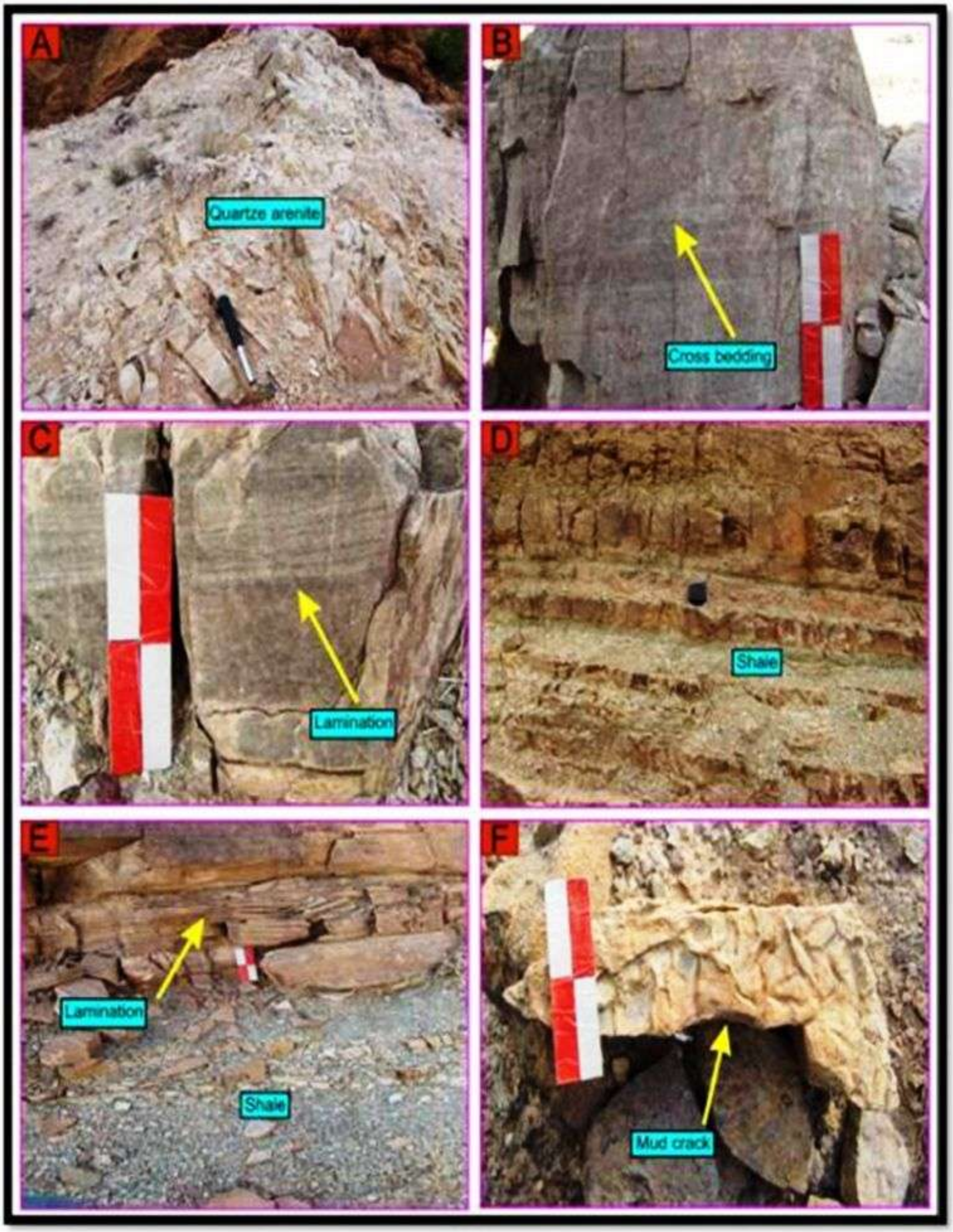


Figure 5: A- White quartz arenite in upper part of section; B- Trough cross bedding in quartz arenite in the upper part of section; C- Parallel lamination in sublitharenite in the middle part of section; D- Intercalation of green shale with brown limestone; E- Green shale in the upper part of the section; F- Mud crack structure in the interface of shale and sandstone.

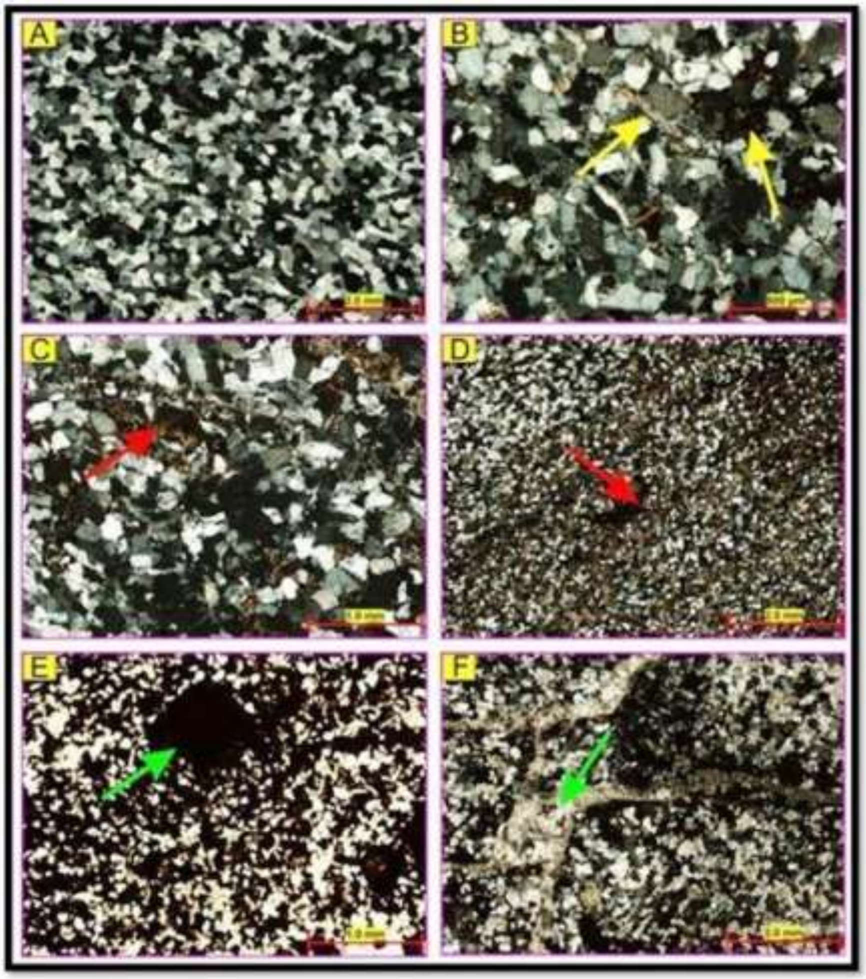


Figure 6: A- Quartz arenite; B and C- Dolomite cement and muscovite in the quartz arenite (arrow); D, E and F- sublitharenite with dolomite cement (D), ferriferous cement (E) and calcite cement (F).

3- Carbonate facies

These facies consists of light-grey, brown and cream beds of fossiliferous limestone. Carbonate microfacies are more abundant than siliciclastic facies in the studied interval. Wide variety of fossils is present in the carbonate facies including brachiopods, gastropods, algaes and corals. Carbonate microfacies have been deposited in different facies belts as tidal flat, lagoon, bioclastic shoal and proximal open marine environments. These facies belts and associated microfacies have been described here.

3-1 Tidal flat facies belt (B)

3-1-1 Sandy limestone (B1)

This microfacies consists of cream, medium to thick bedded limestone which is present in the upper part of the section. Angular fine to medium sand sized quartz grain are present with the amount of about 20-30%. Skeletal fragments of brachiopods and crinoids (about <5%) are also present (Figure 7 A and B). Dolomitization has affected this microfacies.

3-1-2 Bioclastic wackestone (B2)

This microfacies is cream, medium bedded limestone. In thin section it shows wackestone fabric with poorly sorted, sub-rounded detrital quartz (>10%). the main components of the microfacies is bioclasts of different types of fossils. Birdseye fabric is present in the microfacies B2 (Figure 7 C and D).

International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2014 Vol. 4 (1) January-April, pp. 68-84/Ghorbani et al.
Research Article

3-1-3 Sandy dolomitized mudstone (B3)

This facies is characterized by mudstone texture with about 15% subrounded detrital quartz grains. Neomorphism and dolomitization have affected on the microfacies. Evaporate cast and birdseye fabrics are present features in this microfacies (Figure 7 E and F).

3-1-4 Ooid bioclastic packstone (B4)

This facies is composed of dark, thin to medium bedded limestone. The main allochems of this microfacies are umbellina algae, crinoids and radial ooid with micritized core (Figure 7 G).

Interpretation of tidal flat facies belt

Main feature of this facies belt is the existence of sand sized detrital quartz, birdseye fabric, early dolomitization and evaporate cast. These features and association with shoreline facies demonstrate that belongs to tidal flat environment (Bodzioch, 2003). The existence of detrital quartz and birdseye fabric represent deposition in intertidal and supratidal environments (Flügel 2010). High amounts of micrite in microfacies B1, B2 and B3 indicates low energy environment (Adachi *et al.*, 2004).

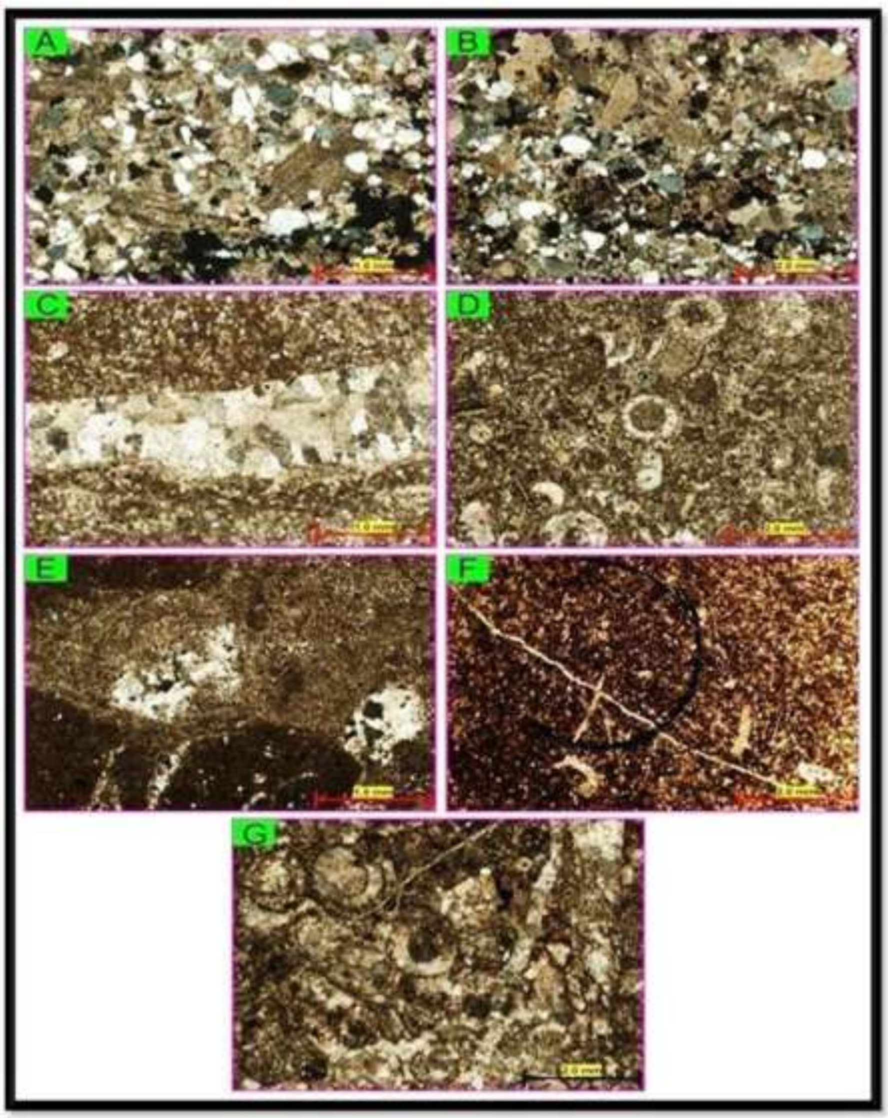


Figure 7: A and B- Sandy limestone microfacies; C- Bioclastic wackestone with calcite veins; D-Bioclastic wackestone with crinoids; E and F- Evaporate molds and calcite veins in sandy dolomitized mudstone; G- Ooid bioclastic packstone with crinoids and secondary calcite cement.

3-2 Lagoon facies belt (C)

3-2-1 Bioclast intraclast peloid grainstone (C1)

This microfacies is composed of grey, thin bedded limestone in the field. The main allochems of this microfacies are peloids (about 60%), poorly sorted intraclasts (10% and mean size of 0.8 mm) umbellina algae and crinoids (Figure 8 A and B).

3-2-2 Bioclast peloid packstone (C2)

This microfacies is grey, thin to medium bedded limestone. It consists of peloid (50%), crinoid and rare fragments of umbellina algae with packstone fabric (Figure 8 C).

3-2-3 Bioclastic umbellina packstone (C3)

This microfacies is characterized by the presence of umbellina algae with the amount of about 30%. Other bioclasts are crinoids and brachiopod. About 5% of detrital quartz grains are also present (Figure 8D).

3-2-4 Bioclastic peloid packstone to wackestone (C4)

About 40% peloid, umbellina algae and brachiopods (rarely) and very fine grained quartz with the amount of 10% are the main components of this microfacies (Figure 8E).

3-2-5 Dolomitized bioclastic packstone to wackestone (C5)

The C5 microfacies consist of gastropods, brachiopods and bryozoans with the texture of packstone to wackestone. This facies has been affected by dolomitization (Figure 8F).

Interpretation of lagoon facies belt

Based on the evidences like low variety of fossils, existence of fossils such as gastropods and umbellina algae, high frequency of pelloid and existence of detrital quartz, it can be concluded that microfacies of C1 to C5 have been deposited in a lagoonal environment (Purser 1973; Tucker and Wright 1990; Flügel 1982; Husince and Sokac 2006; Bachman and Hirsch 2006; Palma *et al.*, 2007).

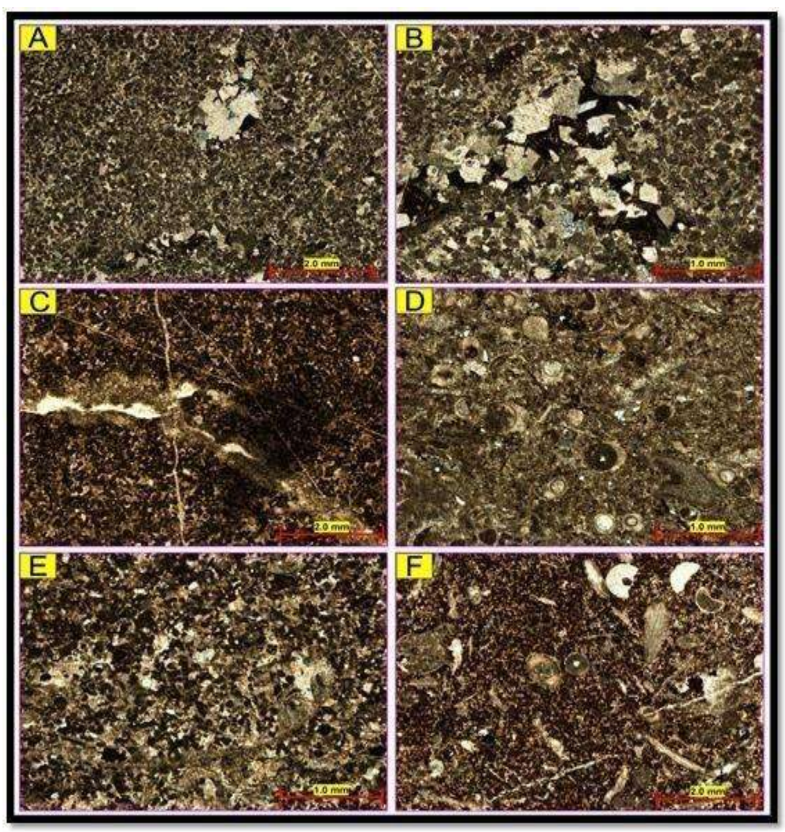


Figure 8: A and B- Bioclast intraclast peloid grainstone; C- Bioclast peloid packstone; D- Bioclast umbellina packstone; E- Bioclast peloid packstone/wackestone; F- Dolomitized bioclast packstone/wackestone.

3-3 Microfacies of barrier facies belt (D)

3-3-1 Coral boundstone (D1)

This microfacies is formed of cream, medium bedded limestone in the lower part of the studied section. It consists of Rugosa corals with massive boundstone texture. Brachiopods and crinoids are subordinate allochems. Coral cavities are filled by cements (Figure 9 A and B).

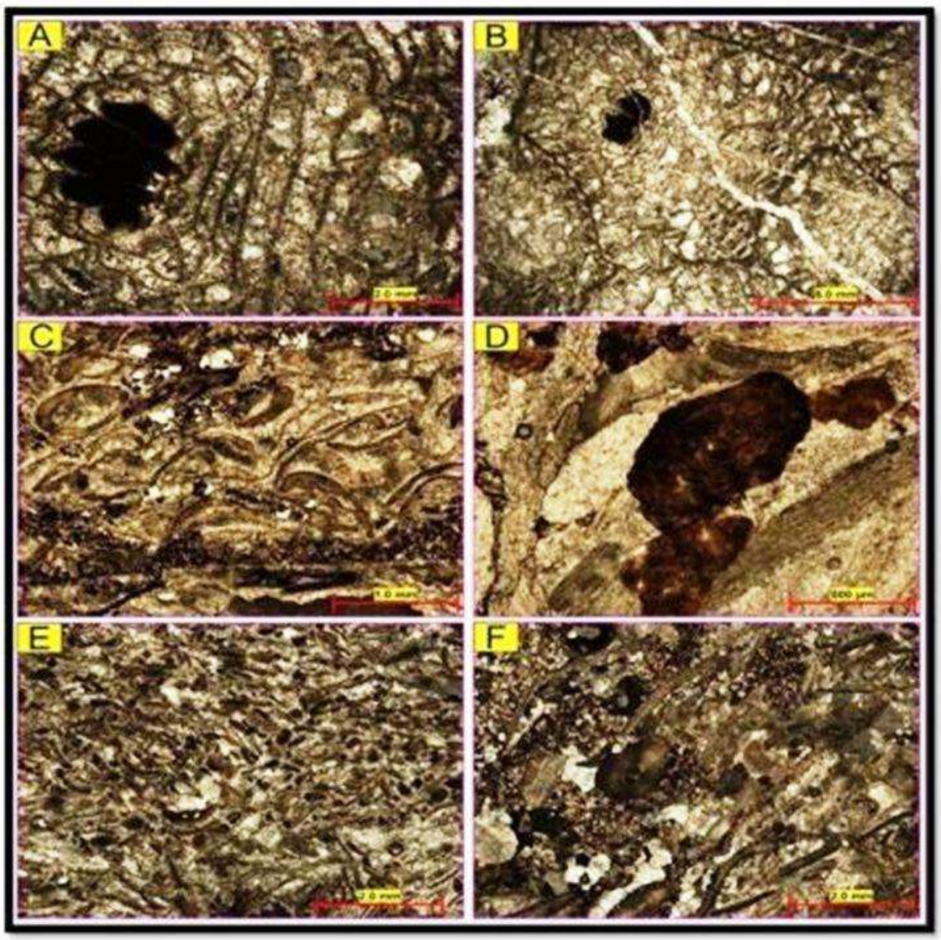


Figure 9: A and B- Iron oxide and calcite vein in coral boundstone; C- Brachiopod shells in the bioclastic grainstone; D- Phosphatization of bioclastic grainstone associated with brachiopods; E- Brachiopods and crinoids in bioclastic grainstone; F- Dolomite in bioclastic grainstone.

3-3-2 Bioclast grainstone (D2)

This microfacies is formed of grey, medium to thick bedded limestone with lamination. Its skeletal grains are: brachiopods (60%) and crinoids and ostracods those are cemented by spary calcite. Its diagenetic features are phosphatic and ferruginous cement, dolomitization and micritization of brachiopods (Figure 9 C to F).

3-3-3 Intraclast bioclastic grainstone (D3)

The D3 microfacies is characterized by the presence of brachiopods (about 40%), crinoids (10%), bryozoans (5%), and intraclast (10% with the mean size of 0.7 mm) (Figure 10 A and B).

3-3-4 Ooid bioclastic grainstone (D4)

This microfacies is a dark, medium bedded limestone with brachiopods (about 30%), crinoids (about 10%), bryozoans (about 5%) and ooid (about 20%). Ooids have been influenced by hematitization, phosphatization and dolomitization (Figure 10 C and D).

Interpretation of Barrier facies belt

Microfacies of D1, D2, D3 and D4 are related to barrier facies. Abundant bioclasts, tangential ooids, lack of micrite and grainstone texture demonstrate deposition in a high energy environment (Tucker *et al.*, 1993; Lucia 1999; Palma *et al.*, 2007; Reolid *et al.*, 2007; Adabi *et al.*, 2010) such as barrier environments (Van Buchem *et al.*, 2002). D4 microfacies have been deposited in seaward barrier (or shoal) because of having phosphatized ooids, brachiopods and bryozoans (Sanders and Höfling, 2000). To create ooids, it needs saline and energetic environment (Flügel 2010, Tucker *et al.*, 1993). Intraclasts in D3 microfacies, represent deposition in the channels of barrier (Tucker and Wright 1990).

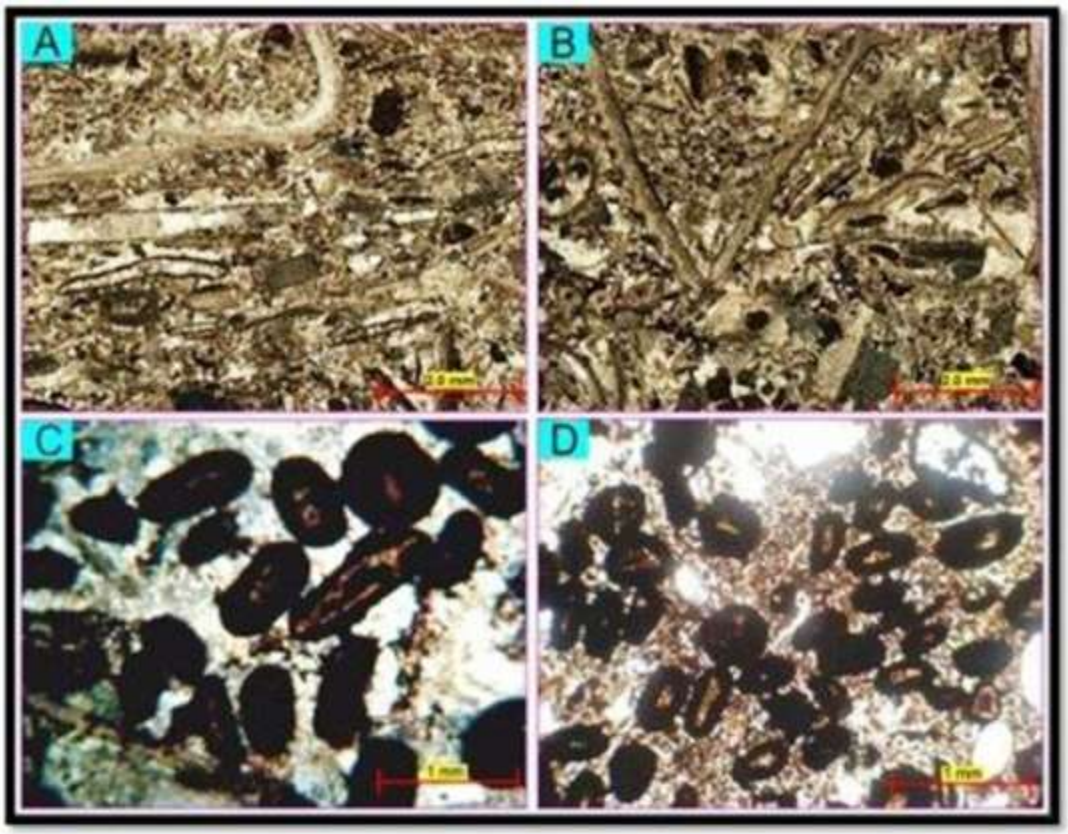


Figure 10: A and B- Brachiopods in intraclast bioclastic grainstone; C- Phosphatized and hematitized ooid bioclastic grainstone; D- Dolomitization in ooid bioclastic grainstone.

3-4 Microfacies of open marine facies belt (E)

3-4-1 Phosphatic Bioclastic grainstone (E1)

This facies is brown, thin bedded limestone and present in the middle and upper part of the studied section (Figure 11 C). The texture of this microfacies is grainstone with abundant fine to coarse grained phosphatic bioclast. Bioclasts are brachiopods, Tentaculitids, Ostracods and crinoids. A few amount of intraclast are also present (Figure 11 A and B).

3-4-2 Bioclastic packstone (E2)

The E2 microfacies consists of brachiopods (about 30%), crinoids (about 10%) and bryozoans (about 5%) with packstone texture. Overgrowth, ferriferous cements and dolomitization are diagenetic features of the microfacies (Figure 11 D, E and F).

Interpretation of open marine facies belt

Brachiopods in E1 microfacies and facies association indicate deposition in the seaward barrier. Intercalation of shale with thin bedded, phosphate bearing limestones confirms shallow open marine environment. The upwelling is led to spread this microfacies (Cook and Shergold 1986). The main allochems in E2 microfacies are coarse brachiopods (>30%), also there are bryozoans. Presence of micrite and lack of detrital grains suggests that deposition has taken place bellow wave base. The presence of stenohaline fauna like bryozoan and brachiopods and the size of bioclasts indicate deposition in the open marine environment (Spalletti *et al*.,, 2001). Bryozoan and brachiopods are sensitive to sea water salinity, so presence of them is a good indicator of low energy environment (Flügel 2010).

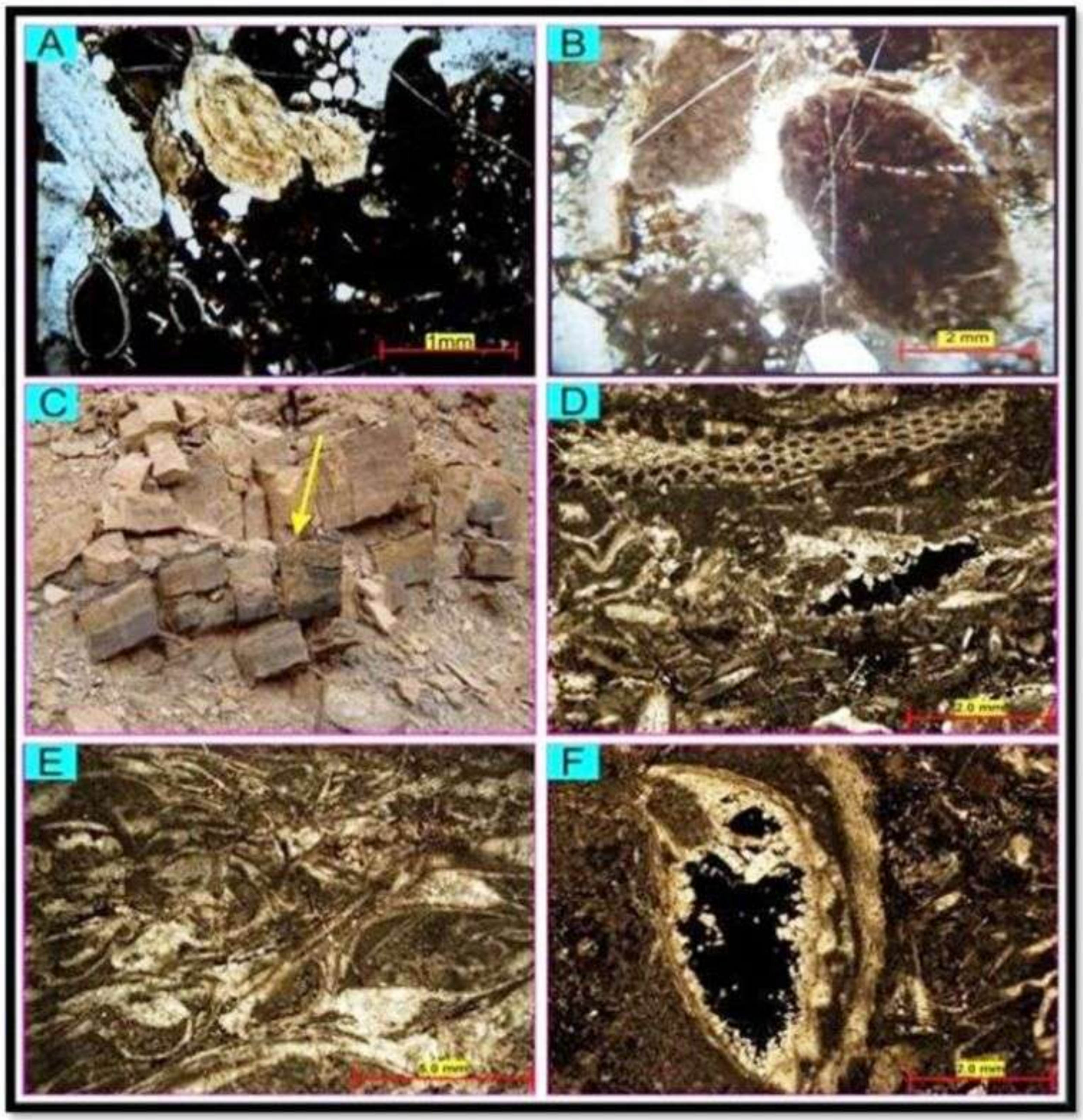


Figure 11: A and B- Phosphatic bioclastic grainstone; C- Brown, thin bedded limestone (consists of E1) microfacies in the upper part of the section; D- Brachiopod and bryozoans in bioclastic packstone; E- Neomorphism in micrite of bioclastic packstone; F- Brachiopod in bioclastic packstone with ferruginous cement.

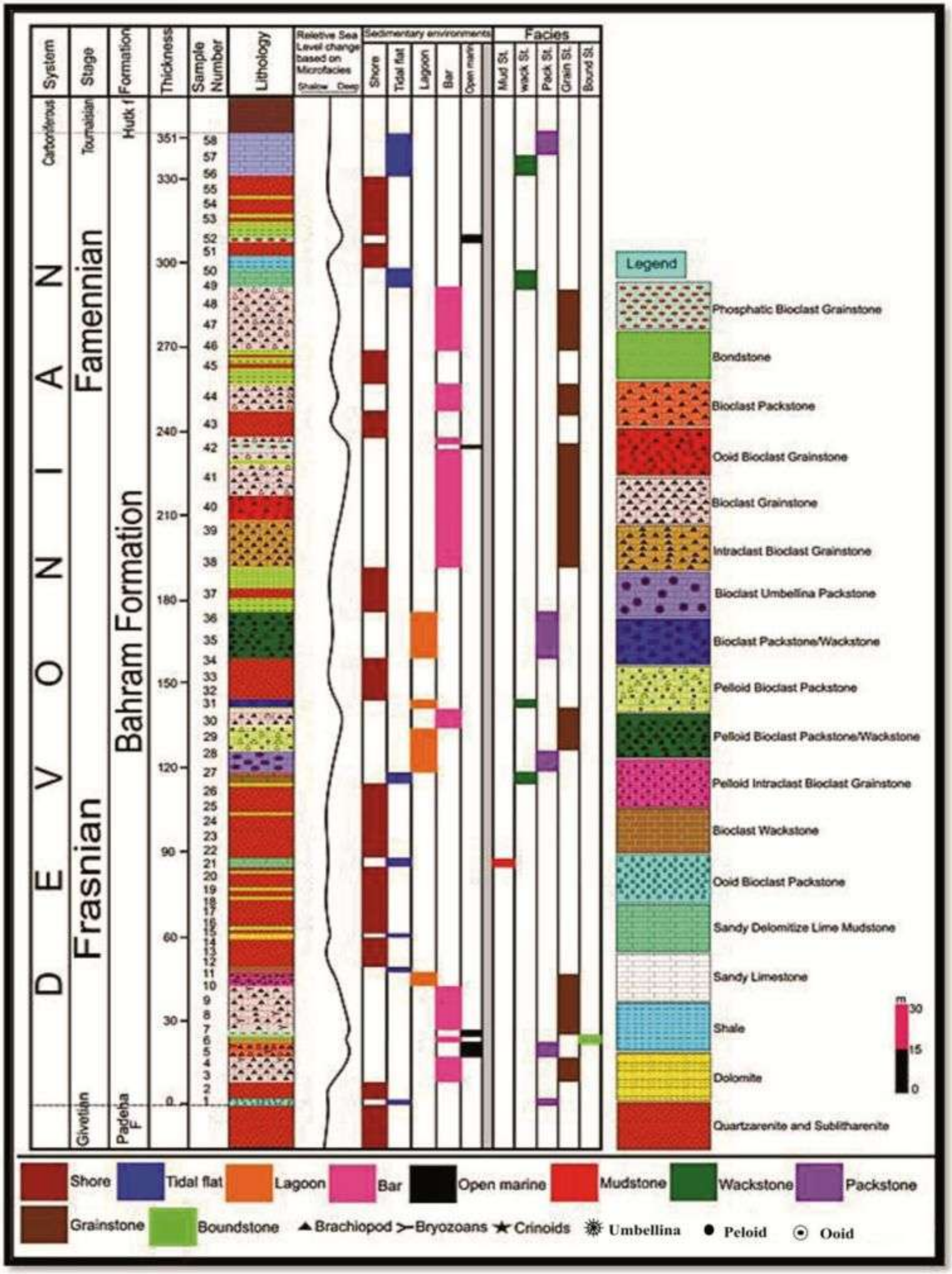
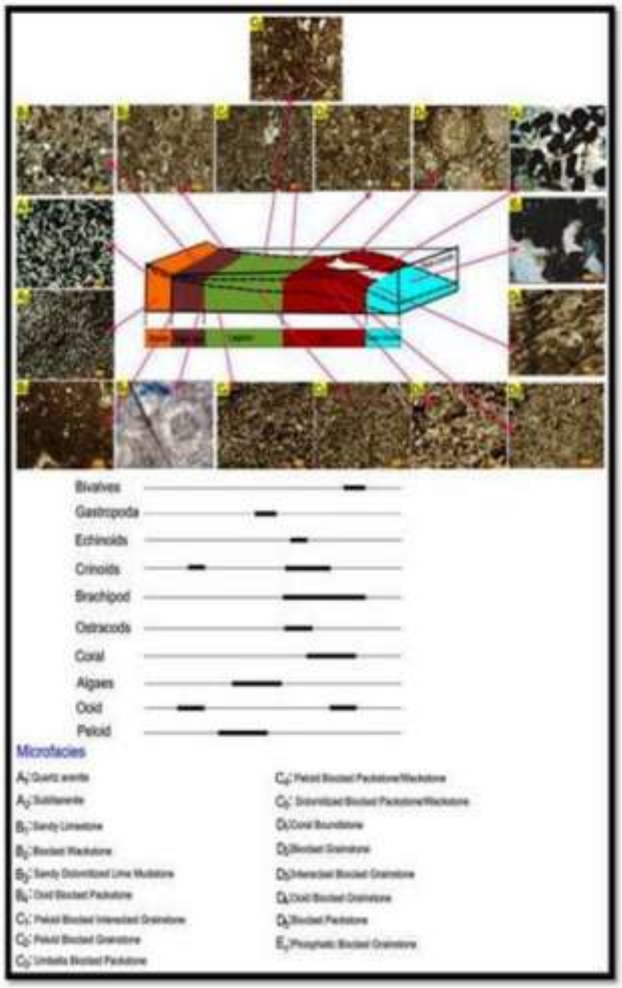
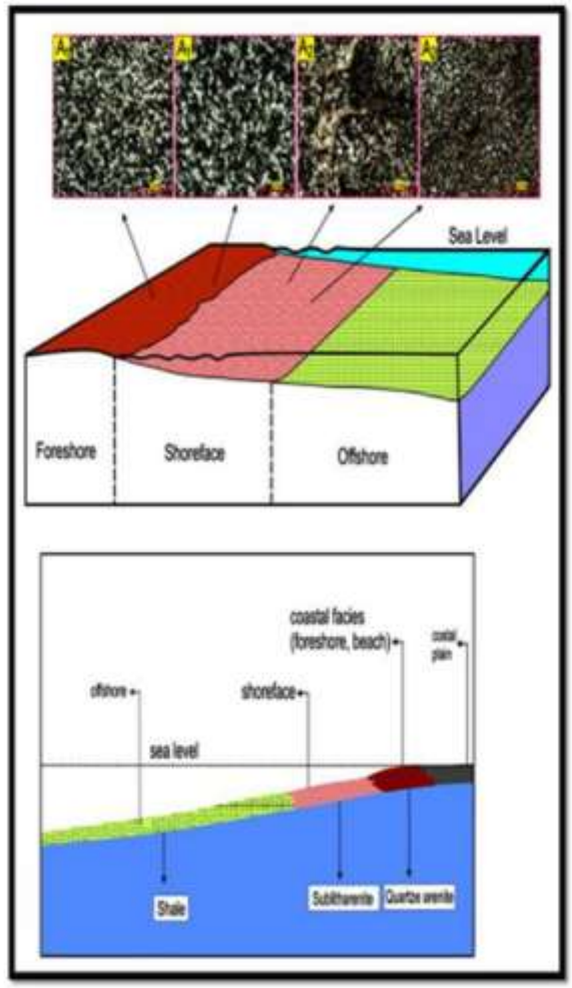


Figure 12: Facies column of the Bahram Formation in the Hutk section.

Depositional model

Based on petrofacies and microfacies, and lateral and vertical variation of facies and accord to Wilson (1975) and Flügel (2010) facies belts; five facies belts have been identified in the Bahram Formation, including tidal flat, lagoon, barrier and open marine (Figure 13 A). Siliciclastic facies and microfacies represent foreshore, shoreface and offshore (Figure 13 B). Base on the lack of barrier reef, falling and sliding facies, (Flügel 2010) redeposited sediment, cortoids, oncoids, pisoids and aggregate grains which belong to rimmed shelf and moreover gradual facies of facies are other evidences that confirm deposition of the Bahram Formation on carbonate homoclinal ramp (Figure 13).





A B

Figure 13: A- Depositional model of carbonate deposits of the Bahram Formation, B- Depositional model of detrital deposits of the Bahram Formation

Conclusions

Based on the field study and petrographic analysis of the Bahram Formation in the Hutk section (north of Kerman) the following conclusions have been achieved.

1. Bahram Formation mainly consists of limestone, sandstone, shale and dolomite with the thickness of about 351 m. This formation is covered the red sandstone of Padeha Formation and is overlain by Carboniferous deposits of Hutk Formation (equivalent of Shishtu 2 Member).
2. Petrographic analysis of the formations caused to identification of 17 facies. These facies have been deposited in 5 facies belt including: shoreface, tidal flat, lagoon, shoal and open marine.

3. Based on lateral and vertical changes of facies (microfacies and petrofacies) ,
4. The lack of barrier reef, sliding and slumping facies, redeposited sediment, cortoids, oncoids, pisoids and aggregate grains which belong to rimmed shelf, and also the gradual change of facies indicates that Bahram Formation has been deposited in the homoclinal ramp with carbonate-siliciclastic deposits.

REFERENCES

Adabi MH Salehi MA and Ghabeishavi A (2010). Depositional environment, sequence stratigraphy and geochemistry of Lower Cretaceous carbonates (Fahliyan Formation), south-west Iran. *Journal of Asian Earth Sciences* **39** 148-160.

Adachi N Ezaki Y and Liu J (2004). The origins of peloids immediately after the ned-permian extinction, Guizhou Province, South China. *Sedimentary Geology* **164** 161-178.

Bachman M and Hirsch F (2006). Lower Cretaceous carbonate platform of the eastern Levant (Galilee and the Golan Heights): stratigraphy and second order sea-level change. *Cretaceous Research* **27** 487-512.

Bodzioch A (2003). Calcite pseudomorphs after evaporates from the Muschelkalk (Middle Triassic) of thy Holy Cross Mountains (Poland). *Geologos* **7** 169-180.

Cook PJ and Shergold JH (eds) (1986). Phosphate Deposits of the World. Vol. 1, Proterozoic and Cambrian Phosphorites. *Results of IGCP Project* 156 xvii 386.

Dastanpour M and Aftabi A (2002). The cause of biomass extinction at the Frasnian- Famennian boundary the Kerman Province southeastern Central Iran. *Islamic Republic of Iran Journal of Sciences* **13** 45-49 Tehran.

Desjardins PR Gabriela M Ángano M Buatois LA and Pratt BR (2010). Skolithos pipe rock and associated ichnofabrics from the southern Rocky Mountains, Canada: colonization trends and environmental controls in an early Cambrian sand-sheet complex. *Lethaia* **43** (4) 507.

Dunham RJ (1962). Classification of carbonate rocks according to depositional texture. *American Association of Petroleum Geologists Memoire* **1** 108-121.

Elliott T (1986). Siliciclastic shorelines. In: *Sedimentary, Environment and Facies* edited by Reading HG 155-188.

Flügel E (1982). *Microfacies Analysis of Limestones* (Springer Verlag Berlin) 673.

Flügel E (2010). *Microfacies of Carbonate Rocks: Analysis, Interpretation and Application* (Springer-Verlag Berlin Heidelberg) 976.

Flügel HW and Ruttner A (1962). Vorbericht ueber Palaeontologisch-Stratigraphische Untersuchungen im Palaeozoikum von Ozbak-kuh (NE Iran). *Jahrbuch der GeoloGischen Bundesanstalt Heft* **1** 146-150.
Vorbericht ueber Palaeontologisch-Stratigraphische Untersuchungen im Palaeozoikum von Ozbak-kuh

Gholamalian H and Kebriaei MR (2008). Late Devonian conodonts from the Hojedk section Kerman Province Southeastern Iran, *Rivista Italiana di Paleontologia e Stratigrafia* **114**(2) 171-181.

Husince A and Sokac B (2006). Early Cretaceous benthic associations (foraminifera and calcareous algae) of a shallow tropical-water platform environment (Mljet Island, southern Croatia). *Cretaceous Research* **27** 418-441.

Lucia FJ (1999). *Carbonate Reservoir Characterizations* (Springer, Berlin) 226.

Morzadec P Dastanpour M and Wright AJ (2002). Asteropyging trilobites from the Late Devonian of the Kerman region Iran. *Alcheringa* **26** 143-149.

Palma RM Lopez-Gomez J and Piethe RD (2007). Oxfordian ramp system (La Manga Formation) in the Bardas Blancas area (Mendoza Province) Neuquen Basin, Argentina: Facies and depositional sequences. *Sedimentary Geology* **195** 113-134.

Pettijohn FJ Potter PI and Siever R (1987). Sand and Sandstone. Springer- Verlag, New York. 553.

Purser BH (1973). *The Persian Gulf Holocene Carbonate Sedimentations and Diagenesis in a Shallow Epicontinental Sea, New York* (Springer- Verlag) 471.

Reolid M Gaillard C and Lathuiliere B (2007). Microfacies, microtaphonomic traits and foraminiferal assemblages from Upper Jurassic oolitic-coral limestones: stratigraphic fluctuation in a shallowing-upward sequence (French jura, Middle Oxfordian). *Facies* **53** 553-574.

Ruttner A Nabavi MH and Alavi M (1965) (Unpublished) geology of Ozbak-Kuh Mountains (Tabas area East Iran). *Geological Survey of Iran* 133.
Sanders D and Höfling R (2000). Carbonate deposition in mixed siliciclastic-carbonate environments on top of an orogenic wedge (Late Cretaceous, Northern Calcareous Alps, Austria). *Sedimentary Geology* **137** 127-146.
Spalletti LA Poire DGE and Schwartz GVD (2001). Sedimentology of a Neocomian Marine Carbonate-Siliciclastic Ramp: Neuquen Basin Argentina. *South American Journal of Earth Sciences* **14** 609-624.
Stocklin J (1972). Iran central septentrional et oriental. lexique stratigraphique international III fascicule 9b Iran 1-283 centre National de la recherché Scientifique Paris.
Stocklin J and Setudehnia A (1991) Stratigraphic Lexicon of Iran. *Geological Survey of Iran* Report 18 1-376.
Tucker ME and Wright VP (1990). *Carbonate Sedimentology* (Blackwells, Oxford) 482.
Tucker ME Calvet F and Hunt D (1993). Sequence stratigraphy of carbonate ramps: systems tracts, models and application to the Muschlkalk carbonate platform of eastern Spain. In: *Sequence Stratigraphy and Facies Associations* edited by Posamentier HW, Summerhayes CP, Haq BU and Allen GP.
Vahdati Daneshmand F, Mahmudi Qaraee MH and Ghasemi A (1995). Geological map of Zarand (1:100000). *Geological Survey of Iran* (In Persian).
Van Buchem FSP, Razin p, Homewood PW, Oterdoom WH and Philip J (2002). Straigraphic organization of carbonate ramps and organic rich intrashelf basins: Natih Formation (middle Cretaceous) of northern Oman. *American Association of Petroleum Geologists, Bulletin* **86** 21-53.
Webster GD Mamples CG Mawson R and Dastanpour M (2003). A cladid-dominated Lower Mississippian crinoids and conodont fauna from Kerman Province Iran and revision of the glossocinids and rhenocrinids. *Journal of Paleontology* **77** (supplement to **3**(35) Lawrence Kansas.
Wendt J Kaufmann B BelkaZ Farsan N and Karimi Bavandpour A (2002). Devonian/Lower Carboniferous stratigraphy facies patterns and palaeogeography of Iran part I northern and southeastern Iran. *Acta Geologica Polonica* **52**(2). 129-168 Warszawa.
Wendt J Kaufmann B Belka Z Farsan N and Karimi Bavandpour A (2005). Devonian/Lower Carboniferous stratigraphy facies patterns and Paleogeography of Iran part II northern and central Iran. *Acta Geologica Polonica* **55**(1) 31-97 Warszawa.
Wilson JL (1975). *Carbonate Facies in Geologic History* (Springer-Verlage, New York) 471.