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Research Article

PETROGRAPHY AND MINERALGY OF GACHSARAN FORMATION IN WEST OF BANDAR -E - ABBAS, KUH- E- NAMAKI KHAMIR SECTION, SOUTH OF IRAN

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ABSTRACT

Gachsaran Formation is the most important cap rock of hydrocarbon reservoir in Iran and has important deposits of salt, sulfur and gypsum. A section of Gachsaran formation (Early to Middle Miocene) in south- east of zagros area, west of Bandar- e- Abbas province, was studied from sedimentary geology view. Gachsaran Formation in studied section, with 310 m thickness consist of Chehel, Champeh and Mol members and consist of gypsum/anhydrite, limestone and marl lithofacies. fourty- four samples has been taken from this section for microscopic examinations and X Ray Diffraction analysis.This research showed that evaporative deposits in Kuh-e- Namaki Khamir section, contain of gypsum, anhydrite, dolomite and halite minerals and marl deposits contain of palygorskite, dolomite and calcite minerals and carbonate deposits contain of dolomite and calcite minerals. The mineralogical composition and lithological characteristics, confirm that Gachsaran Formation in the study area has deposited in lagoonal to Sabkha environment with warm and dry climate and limit regress and progress of sea.

Keywords: Petroghraphy, Mineralogy, Bandar e Abbas, Gachsaran Formation

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1. INTRODUCTION

Extensive accumulations of evaporite minerals are very common in stratigraphic sequences of Phanerozoic eon. Evaporite deposits presence from the Late Precambrian to recent and make up of 25 percent of the continental areas and two percent of the Phanerozoic rocks [1]. Study of mineralogy and petrograghy are important in research of sedimentation and diagenetic processes of these rocks. They are provide a unique information to reconstruction of depositional environment and paleo-climate [2].

The Zagros basin is defined by a 7–14 km thick succession of cover sediments deposited over an extraordinary wide and long region along the north–northeast edge of the Arabian plate. The resulting stratigraphic column of Phanerozoic deposits in the Zagros basin contains evaporites at different levels in different parts. Of these, the Neo-Proterozoic, Hormuz series located at the base sedimentary column and the Gachsaran Formation (Early-Middle Miocene) higher in the Zagros stratigraphic column are thickest and most wide spread evaporitic units [3]. Gachsaran Formation and time-equivalents of this that all extend about 1500 km from the SE to NW, from the Arabian Emirates, through Arabia, Iraq, and Turkey to Syria and it is the most important cap rock of hydrocarbon reservoir in Iran [4].

Despite many geological studies of the Gachsaran formation in hydrocarbon fields, there are few detailed reports of the sedimentology and mineralogy of the Gachsaran Formation in south- east of Zagros zone (Bandar Abbas Hinterland). The present study attempts at using the mineralogical study by Xray Diffraction method and petrographical characteristics of Gachsaran Formation deposites in west of Bandar- e- Abbas province in Iran to delineate the paleo-climate and mechanism of depositional environment.

2. METHOD

A total of 44 samples were collected from different lithological units of Gachsaran Formation in the selected section. A Phillips (PW1800) X-ray diffraction spectrometer, at the Kansaran Binalud in Tehran, was used for 19 samples to determination of mineral phases. 25 thin sections were prepared, and examined under the polarizing microscope to delineate their mineralogical and textural characteristics.

3. GEOLOGICAL SETTING

Hormuzgan province is located in south of Iran and north the Strait of Hormuz. The section studied is located 65 km west of bandar e Abbas on the western flank of the Khamir salt dome mountain (fig. 1). It can be accessed via the road from banadar e pohl towards bandar e Khamir. The section was measured 1 km north of the road at N 27˚02′25″ to N 27˚02′44″ latitude, E 55˚42′00″to E 55˚42′06″ longitude (Fig 1).

The studied area is a part of the south- eastern end of the folded zagros zone (Bandar- e- Abbas Hinterland), which consists of a simple anticline- syncline system [5]. The hormuz series is the oldest exposed unit in the Zagros Mountains and is composed of rhyolites, basalts, carbonates and evaporites. According to stöcklin and setudehnia (1991) and Aghanabati (2004) [6, 7] this series is of late Precambrian to early Cambrian age. In the studied area the hormuz series is overlain by the Asmari and jahrum formations. These, in turn, are covered by the Gachsaran Formation and the overlying Mishan Formation (Fig 2).

Gachsaran Formation in west of Bandar- e- Abbas, with 310 m thickness consist of Chehel, Champeh and Mol members. Gachsaran Formation lithology, consists of alternations of calcium sulphates, marls and carbonates (Fig 3). This formation in Kuh e namaki Khamir section, overlies the Asmari Formation with a transitional boundary. Upper boundary with Mishan Formation is erosional and defined by a horizon of paleosol. Field observation and laboratory studies led to identification of gypsum/anhydrite, limestone and marl facies.Petrography and mineralogy of each lithofacieses will be described in more detail in a following section.

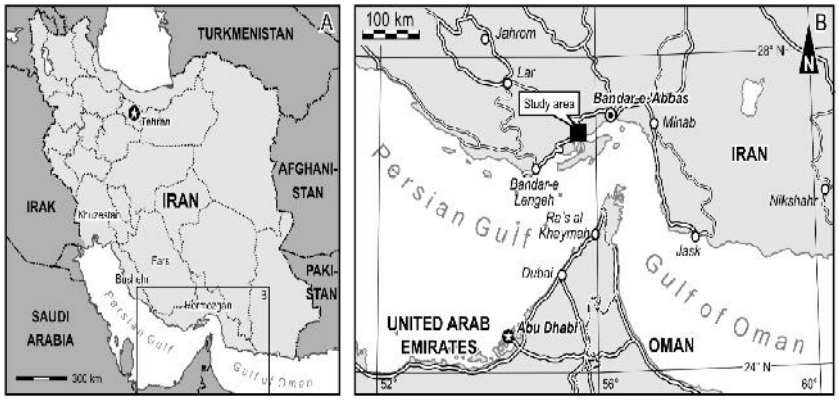

Fig.1. Location of the studied area in south of Iran. (b) Detailed position of the studied area in Hormozgan province

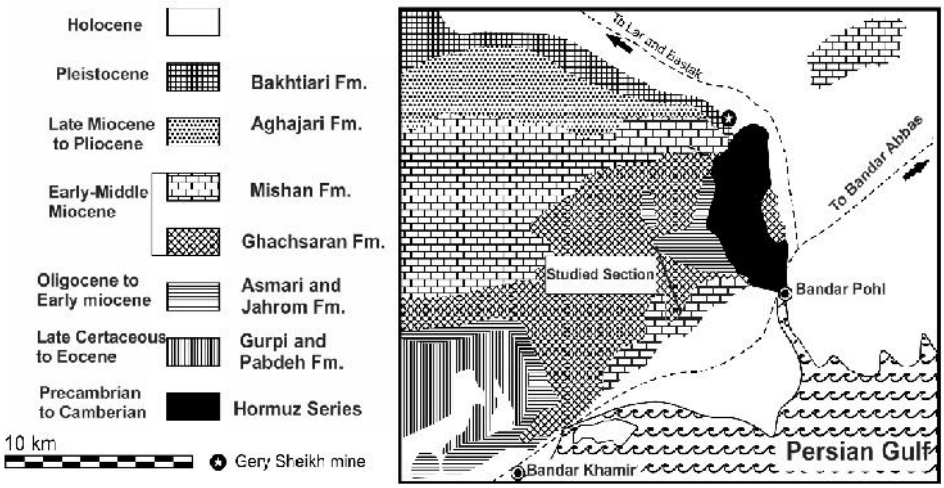

Fig.2. Geological map of the studied area

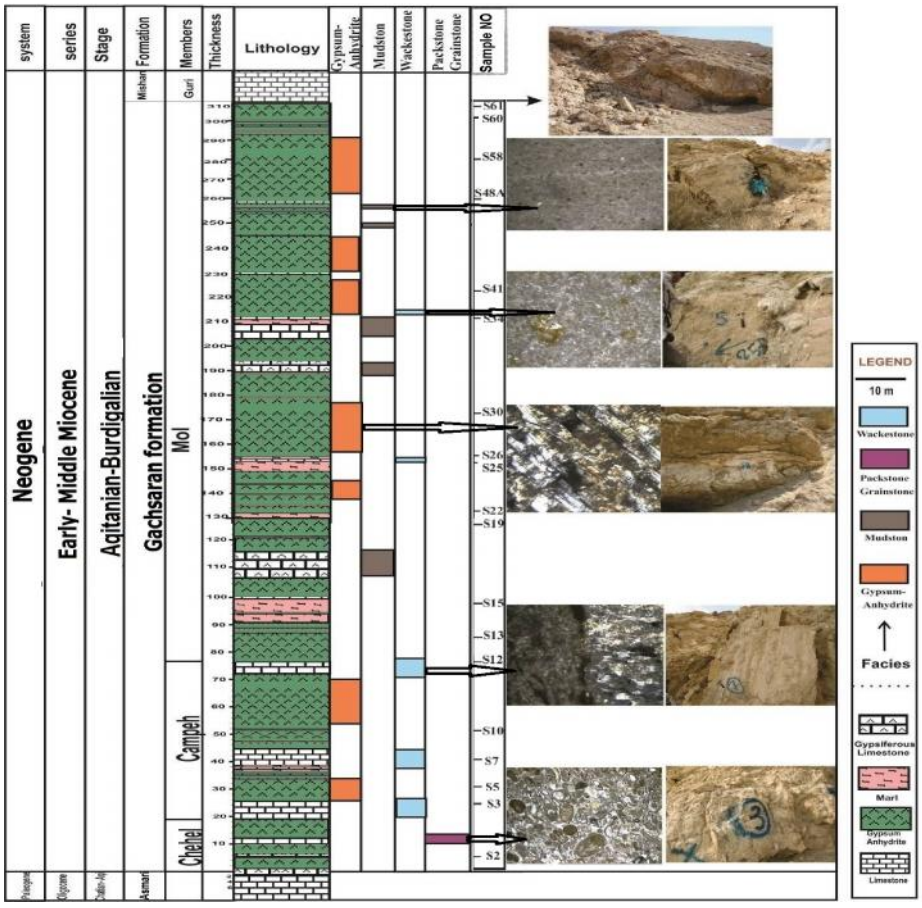

Fig.3. Stratigraphic column of Gachsaran Formation in west of Bandar- e- abbas (Salari and rezaee, 2015) [8].

4. RESULT

4.1. Petrography and mineralogy of gypsum - anhydrite facies

Calcium sulphates of Gachsaran formation were alternated with marls and carbonates. These rocks constitute about 80% lithofacies of the Gachsaran Formation in the studied section. Gypsum - anhydrite minerals were the most important components of this facies. The field observations revealed the nodular and laminar structures within calcium sulphates of Gachsaran Formation. Some sulphate beds are massive with no nodular structure (Fig 4A). Sulphate nodules are composed either of gypsum or anhydrite with stringers of calcite between nodules. Gypsum nodules with mosaic or “chicken-wire" structure are very common. They have spherical and elongated shapes ranging in size from 1 to 3 centimeters in diameter (Fig 4B).

Laminated anhydrites, consist of thin, nearly white anhydrite laminations that alternate with dark-gray laminae rich in dolomite or calcite. The laminae are commonly only a few millimeters thick and rarely attain a thickness of one centimeter (Fig 4c). Massive gypsum- anhydrite is a homogeneous rock with dispersed impurities or diffuse laminae of clay and carbonate, which are remains of primary bedding. In petrographic examination, gypsum crystals can be identified by characteristic lath-like crystal shapes, weak birefringence and low reliefs (gray to white). Anhydrite is distinguished from gypsum by a higher relief and stronger birefringence (up to third order). Under polarizing microscope, gypsum and anhydrite crystals take a variety of forms that include needle, fibrous and radial clusters of crystals (Fig 5A, B, and C).

During diagenesis, anhydrite and gypsum can transform from one to the other by the gain or loss of bound water. In some sample dehydrated gypsum to anhydrite, losing much of its original crystal form and becoming irregular bladed crystals (Fig 5D). X-ray diffraction analyses of the available thin sections revealed the presence of the different proportion of the minerals stated above. The X-ray diffractogram of representative sample (Fig 6) shows that there are three dominant minerals: gypsum, anhydrite and halite. Palygorskite, quartz and bassanite minerals was also identified by X-ray diffraction, but not in thin sections. Halite is remarkable as major and minor phase in the upper part of Gachsaran Formation samples. Major, minor and trace Phases minerals of evaporites deposites of Gachsaran Formation by XRD be seen in table 1.

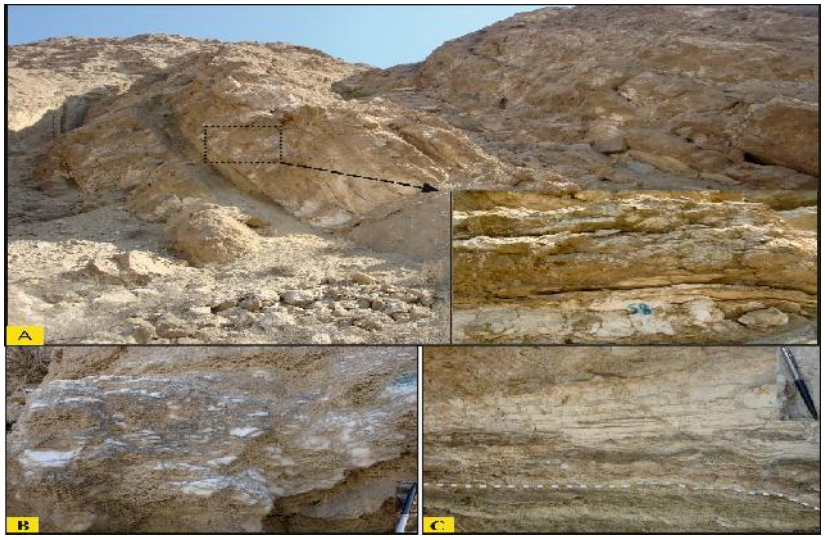

Fig.4. Outcrop photograph of evaporite rocks: A, massive sulfates. B, “chicken-wire” anhydrite here has replaced and displaced micritic sediment. As anhydrite nodules grow and coalesce, remnants of the original carbonate material is compressed into thin zones that separate the nodules. C, Laminated evaporite from the Gachsaran formation: white anhydrite laminations alternate with dark-gray laminae rich in calcite.

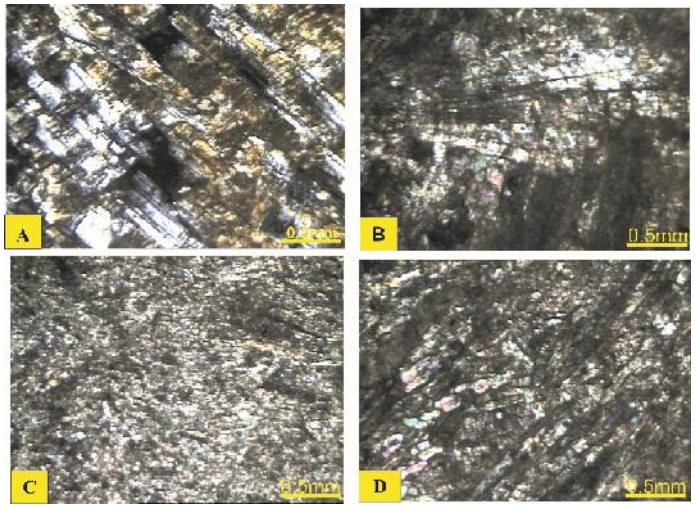

Fig.5. A, Fibrous texture of anhydrite (XPL). B, Fibrous radial texture of anhydrite (XPL). C, Needle crystals of gypsum –anhydrite (XPL). D, Irregular bladed crystals of gypsum dehydrated to anhydrite (XPL).

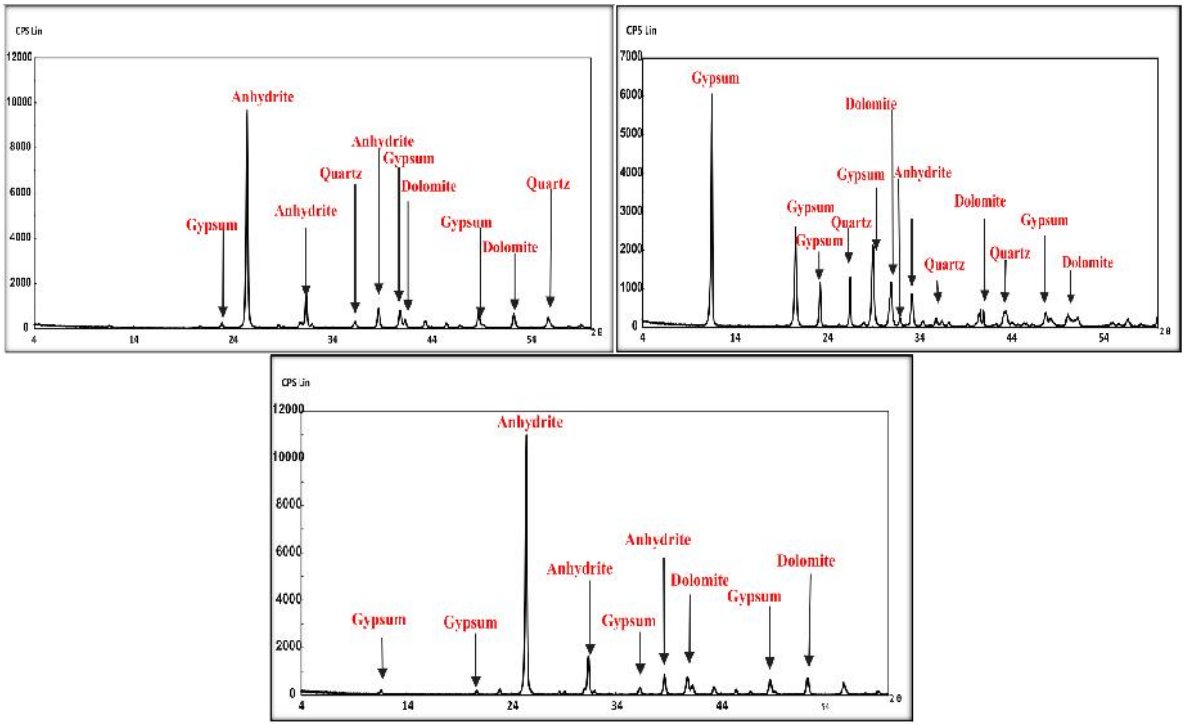

Fig.6. Representative X-Ray Diffractograms of three evaporite samples from lower, middle and upper members of Gachsaran Formation in studied section (Respectively from top to bottom, Samples S2, S13, and S58).

Table 1. Major Phase (s): ∗, Minor Phase (s): + and Trace Phase (s): / minerals in evaporites deposites of Gachsaran Formation by XRD

Mineral \ Sample	S2	S5	S10	S13	S19	S30	S41	S58	S61
Anhydrite- $CaSO_4$	*	*	+	+	+	+	*	*	+
Gypsum- $CaSO_4.2H_2O$	+	+	*	*	*	*	----	+	*
Dolomite- $CaMg(CO_3)_2$	----	+	----	*	+	----	----	+	*
Calcite- $CaCO_3$	---	---	----	----	----	+	----	----	----
Quartz- SiO_2	----	/	+	/	+	+	/	----	+
Halite- NaCl	----	---	----	----	----	/	*	----	/
Palygorskite $Mg_5(Si,Al)_8O_{20}(OH)_2,8H_2O$	/	---	----	----	----	+	+	----	----
Bassanite- $CaSO_4\_1/2H_2O$	----	/	----	----	----	/	----	----	----

4.2. Petrography and mineralogy of carbonate facies

Carbonate bed of Gachsaran Formation with gray, white and brown colours were alternation of marls and evaporate deposites. Carbonates make up about 10% of total sediments in studied section (fig. 7).

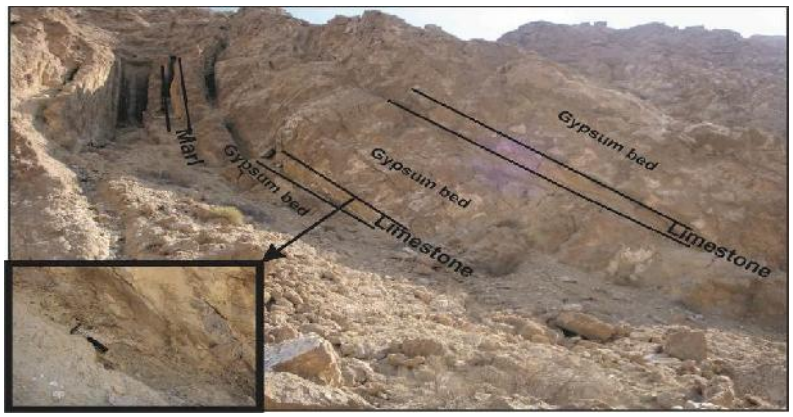

Fig.7. Carbonate beds (Limestone) were alternation of evaporite deposites in upper member of Gachsaran Formation.

Facies and microfacies analyses of carbonate beds were based on field observations and the study of thin sections. Petrographic Study of thin sections led to identification of dolomitzed lime mudstone, gypsum- anhydrited lime mudstone, laminated silty lime mudstone, dolomitzed bioclast packstone – grainstone and fenestral dolomitzed intraclast wackestone microfacies following Dunham's classification of carbonate rocks (1962) (Fig.8 A, B, C, D, E and F). Lime mudstone making up 72% of the Gachsaran formation carbonates by abundance and contain of very fine-to-fine crystalline dolomite. Dolomite crystals are made of shapeless anhedral to subhedral. Size of crystals is less than 50 microns µm in size. Features such as fenestral fabric, evaporate molds, and anhydrite nodules in a dolomicrite matrix are observed abundantly in this microfacies.

The results of XRD analysis of three carbonate samples in the study section is presented in Figure 9. As seen in the figure, the major minerals consist of dolomite and calcite. The data summarised in Table 2 shows that the carbonates of studied section, consists of gypsum, anhydrite and halite in minor phase. Dolomite was identified by X-ray diffraction, but not in all thin sections. Hence, it must be restricted to the matrix, in the form of very fine grain crystals, in the studied samples.

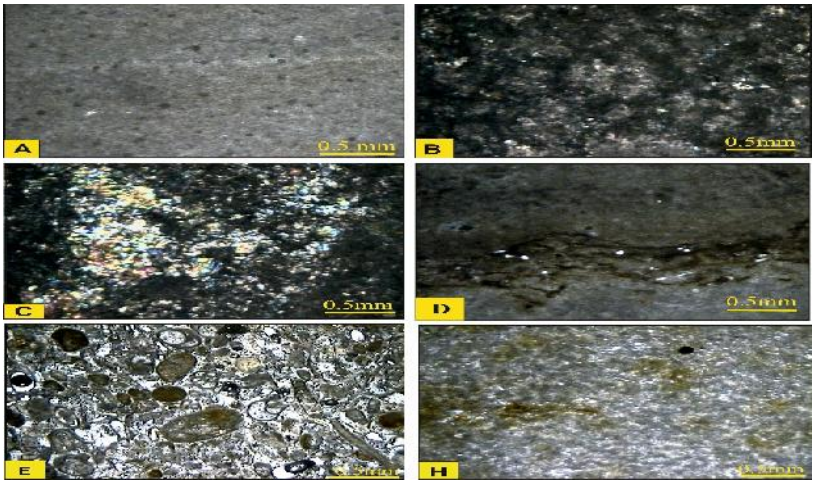

Fig.8. A, Lime mudstone (XPL). B, Gypsum- anhydrite lime mudstone (XPL).C, Dolomitized lime mudstone with fenestral fabric (XPL). D, Silty laminated limemudstone. E, Dolomitization in bioclast packstone-grainstone (XPL). H, Dolomitized wakstone with fenestral fabric (XPL).

Table 2. Major Phase (s):∗, Minor Phase (s): + and Trace Phase (s): / minerals in carbonate beds of Gachsaran Formation by XRD

Sample / Mineral	S3	S12	S26	S48A
Anhydrite - $CaSO_4$	+	+	+	+
Gypsum - $CaSO_4.2H_2O$	+	*	+	+
Dolomite - $CaMg(CO_3)_2$	*	*	*	*
Calcite - $CaCO_3$	+	*	*	----
Quartz - SiO_2	----	/	----	+
Halite - NaCl	----	----	+	/

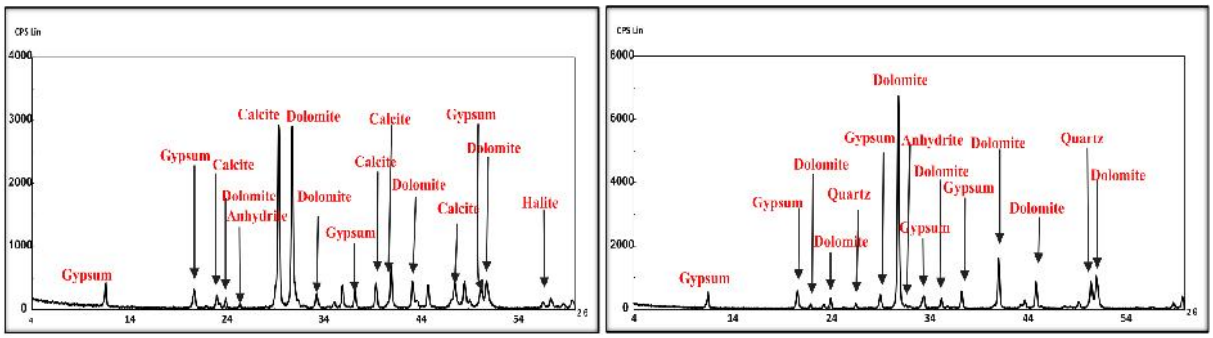

Fig.9. X-Ray Diffractograms of Carbonate beds of Gachsaran Formation (Samples S12 and S48).

4.3. Petrology and mineralogy of Marl facies

Marls of the Gachsaran Formation are cyclic arranged with the limestone and sulfates. These Marls have thickness from .3 to 8 metres, olive green colour, non-fossil and apparently structureless (Fig 10 A). Veins and fractures filled fibrous satinspare CaSO4 are widespread in the mal beds adjacent to evaporate units undergoing dissolution (Fig 10 B). Most fracture fills are mono mineralic and gypsum is the dominant mineral in most near surface fracture systems. Very thin limestone beds are occasionally present within these rocks.

The preparation thin sections being difficult from marls, facies analyses of marl interbeds were realised from field observations only. X-ray powder diffraction is the best available technique for the identification and quantification of all minerals present in clay-rich rocks (mudstones, and marls). X-ray diffractograms of marl deposite from Gachsaran Formation are shown in Fig 11. Mineralogy of these marls has revealed that finegrained dolomite, calcite, gypsum and clay minerals form the main constituents. Palygorskite is very important and common clay minerals in in Ghachsaran Formation marl samples (Table 3).

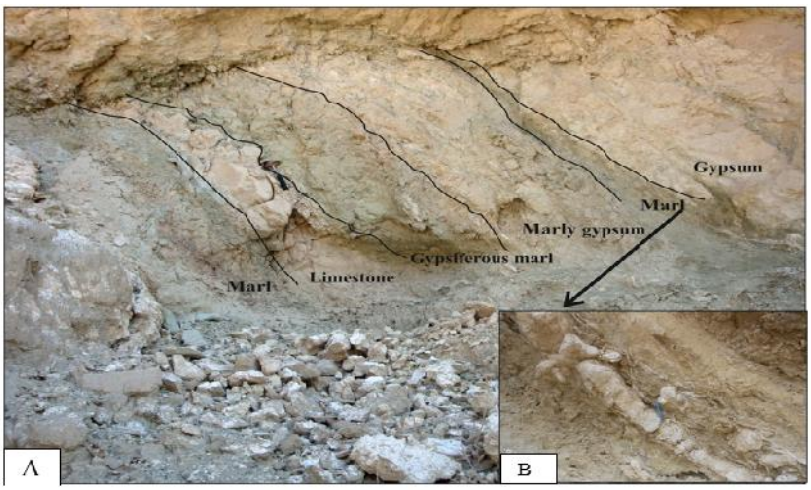

Fig.10. A, Marls of the Gachsaran Formation are cyclically arranged with the limestone and evaporates. B, Meshwork of satinspar gypsum veins created by dissolution of adjacent anhydrite bed (pen for scale).

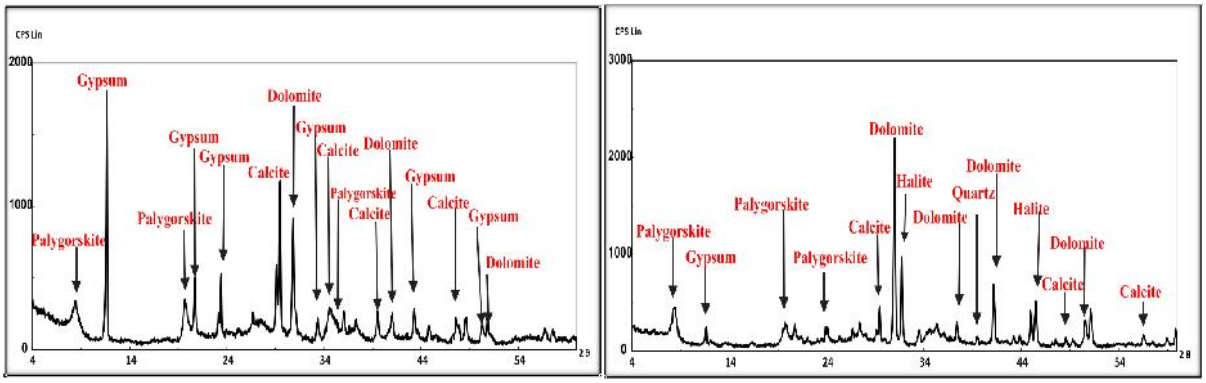

Fig.11. X-Ray Diffractograms of Marl beds of Gachsaran Formation (Samples S7 and S60).

Table 3. Major Phase (s): ∗, Minor Phase (s): + and Trace Phase (s): / minerals in green marls of Gachsaran Formation by XRD

Sample / Mineral	S7	S15	S22	S25	S34	S60
Palygorskite $Mg_5(Si,Al)_8O_{20}(OH)_2,8H_2O$	*	*	*	*	*	*
Dolomite - $CaMg(CO_3)2$	*	*	*	*	*	*
Gypsum - $CaSO_4.\ 2H_2O$	+	+	+	*	*	+
Calcite - $CaCO_3$	+	-----	-----	*	*	+
Anhydrite - $CaSO_4$	+	+	+	+	+	+
Quartz - SiO_2	+	+	+	+	+	+
Halite - NaCl	+	-----	/	-----	*	*
Crysotile - $Mg_3Si_2O_5(OH)_4$	-----	-----	-----	-----	/	/
Albite - $NaAlSi_3O_8$	-----	-----	-----	-----	/	/

5. DISCUSSION

Evaporatic carbonates are the first evaporate minerals to precipitate from a concentrating hyper saline surface water and are usually composed of aragonite, calcite, magnesite and primary dolomite [2]. In studied section, carbonate beeds are generally associated and alternated with massive, bedded and nodular gypsum-anhydrite intervals. They are massive and-or laminated dolomitized lime mudstone, gypsum- anhydrited lime mudstone, silty lime mudstone, dolomitzed bioclast packstone – grainstone and fenestral dolomitzed intraclast wackestone microfacies. The most carbonate rocks in studied section are mainly represented by gray massive

dolomitized lime mudstones.Fenestral fabric in Lime mudstones, caused by wetting and drying of carbonate mud in supratidal settings and suggest low energy conditions [9]. The mudstones are generally composed of microcrystalline dolomite. Supratidal dolomites are typically microcrystalline (1-5 μm), with weakly ordered crystal structure. These dolomites are found within muddy carbonate sediments or as surface crusts on supratidal flats. Dolomitization is explained as being formed by hypersaline brines derived from intense evaporation in sabkhas. Dolomite replaces preexisting metastable carbonate sediment. Dolomitizing solution is a brine with a high Mg/Ca ratio resulting from Ca removal through precipitation of gypsum or anhydrite. Interbedded lime mudstones and layers with anhydrite or gypsum crystals Common in Upper intertidal to supratidal sabkha facies (FZ 9A) in arid and semi arid coastal plains and evaporitic lacustrine basins [10].

Evaporate facies are deposited in a brine pan or seaway after the brine pricipitated the carbonates [2]. Abundant evaporite minerals are chlorides (halite) and sulfates (gypsum and anhydrite). Sulfate deposite of Gachsaran formation, are composed dominantly of varying proportions of anhydrite ($CaSO_4$), gypsum ($CaSO_4.2H_2O$) and halite (NaCl) minerals. Gypsum begin to form when the original volume of seawater is reduced by evaporation to about 20 percent. Gypsum is by far the most abundant calcium sulfate mineral that forms under normal sedimentary conditions. Anhydrite forms rarely at the surface, but only in arid and hot supratidal environments (sabkha) in the presence of concentrated brines [11, 12, and 13].

The thick deposition of nodular gypsum may represent the sediments of a very shallow, arid, semi restricted marine environment [14]. Upper intertidal and supratidal sabkha sediments are characterized by gypsum, landward areas by anhydrite nodules and chicken-wire anhydrite, often hydrated to gypsum [10]. Bassanite mineral has been found in some sulfates sampels of Gachsaran formation. Bassanite is a metastable mineral where gypsum and anhydrite are in transition [15]. Intense solar heating in arid regions can dehydrate gypsum to form bassanite-anhydrite at the surface [2].

Mineralogy of marls in studied section, has revealed that dolomite, calcite, gypsum and clay minerals form the main constituents. Clay mineralogy of the studied Miocene successions gave an important indication for the paleoenvironmental aspects of these successions. Palygorskite is a common mineral in lower, middle and upper Marls of Gachsaran Formation, depending on the results of X-ray diffraction. Palygorskite is a fibrous clay mineral and is commonly associated

with dolomite and other Mg- rich minerals. Chamley (1989) [16] has shown that palygorskite derives from chemical precipitation in evaporative basins. He summarized the conditions for palygorskite formation as "alkaline conditions in restricted basins subject to marine transgression, limited water exchange, semi-arid climatic conditions and strong evaporation". The lithofacies association of the palygorskite with dolomite and gypsum reflects lagoonal, brackish hypersaline, alkaline waters and Mg-rich environments - for the authigenic formation of the mineral [17]. Marl beds of the Gachsaran Formation were deposited in a lagoonal, relatively saline environment. These conditions are suitable for the formation of palygorskite as neoformed clay mineral in restricted, evaporitic lagoons of the marl beds of the Ghachsaran Formation.

6. CONCLUSION

Gahsaran Formation (Early to middle Miocene) in west of Bandar- e- Abbas, south of Kuh- e- Namaki Khamir, overlies the Asmari Formation with a transitional boundary. Upper boundary with Mishan Formation is erosional and defined by a horizon of paleosol. Sequence components of marl, limestone and gypsum anhydrite facies, represents the back carbonate ramp. Mineralogical compositon with sedimentary characterize, confirm that Gachsaran Formation in studied section has deposited in lagoonal to sabkha environment with warm and dry climate and limit sea level changes.

7. REFRENSES

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