Asian Journal of
Earth Sciences

ISSN 1819-1886

Academic
Journals Inc.

www.academicjournals.com

Asian Journal of Earth Sciences 7 (1): 17-26, 2014
ISSN 1819-1886 / DOI: 10.3923/ajes.2014.17.26

Depositional Environment Interpretation of Lar Formation (Upper Jurassic) Based on Study of Clay Mineralogy and Microfacies in East Azarbaijan (North Western of Iran)

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ABSTRACT

Microscopic and field studies on the Lar formation in south west of Azarshahr in Haft-Cheshme anticline section is due to separate of three part of marl, marly carbonate and carbonate in this formation. According to microfacies and macroscopic fossils in carbonate section, open marine environment were identified from a carbonate ramp. XRD test samples related to clay marl in the low and middle part indicated existence of clay mineral such as illite and cholorite from clastic origin in the part of upper and middle marl and illite and smectite are diagenetic origin in the lower marl. The simultaneous presence of the minerals in the middle marl and the lack of smectite in this section represent of temperate climate conditions are during deposition of the middle marl. The semi-quantitative analysis of the XRD is indicating of smectitec increasing and illite decreasing in the lower marl part which it may represent of a warming climate and depth sea relative increase and it was consistent with sea level change global. Important digenetic process of identified in these formations are include: Cementation, primary and secondary porosity and chert nodules formations (constituents) which the secondary porosity is more than a fracture and channel types. The existence of these fractures has created suitable underground water aquifers in this area.

Key words: Lar formation, XRD, carbonate ramp

INTRODUCTION

Identifying and naming of studied sections components and surveys of diagenetic processes are important in the determination and study of microfacies and sedimentary environment interpretation (Flugel, 2010).

On the other hand, the clay minerals can were used in determine the sedimentary environment and deposits diagenetichistoric (Jackson, 1979). Clay minerals, hydreous aluminum silicates is layer structure and they are classified as sheet silicates (Hardy and Tucker, 2004).

A unique characteristic of these minerals are including formed of the surface and subsurface different conditions. XRD analysis is important in determining the exact of clay minerals type and the semi-quantitative analysis of clay minerals (Jeong *et al*., 2004).This study investigated depositional environment and a digenetic conditions of the Lar formation depositions based on study of clay minerals and microfacies in the Haft-Cheshmeh anticline section in southwest of Azarshahr.

MATERIALS AND METHODS

Study area: The Haft-Cheshmeh is located in 45°42' 43" E and 37°41' 80" N in east Azarbaijan province with 7495 km^2 in about 18 km the south west of Azarshahr (Fig. 1). This area is part of the western Alborz-Azarbaijan (Aghanabbati, 2005). There are deposits of belonging to the Jurassic, Cretaceous and Quaternary outcrops in this study area (Assereto, 1966). Jurassic deposits is include of marl (Delichay formation, middle Jurassic), marl and limestone (Lar formation, late Jurassic), Cretaceous deposits are consist of limestone (Tizkuh formation, early Cretaceous), shale and deposits are not named (late Cretaceous) and Quaternary deposits are include of alluvial terraces of ancient, travertine and alluvial terraces of young (Steiger, 1966) (Fig. 2).

Methods: This study was investigated based on fields and laboratory studies which these are one of the commonly methods in sedimentary geology. In the field studies, sampling of the formations are done with change of fancies and vertical of along the layers.

Hereby, eighty samples prepared of lower, middle and upper parts from the formations of study area and then the formation lithostratigraphy column has been plotted. Moreover, seventy thin

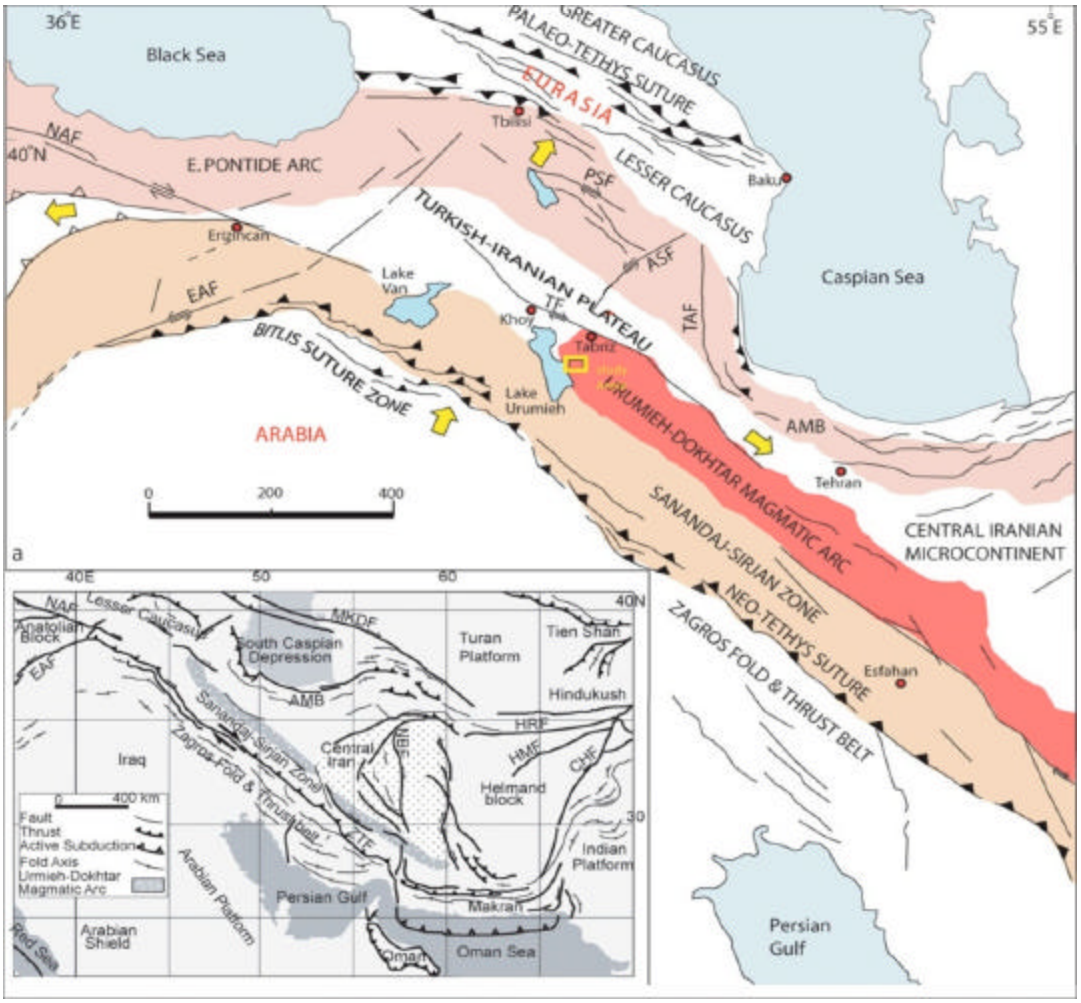

Fig. 1: Study area in Iran, west Azarbaijan province

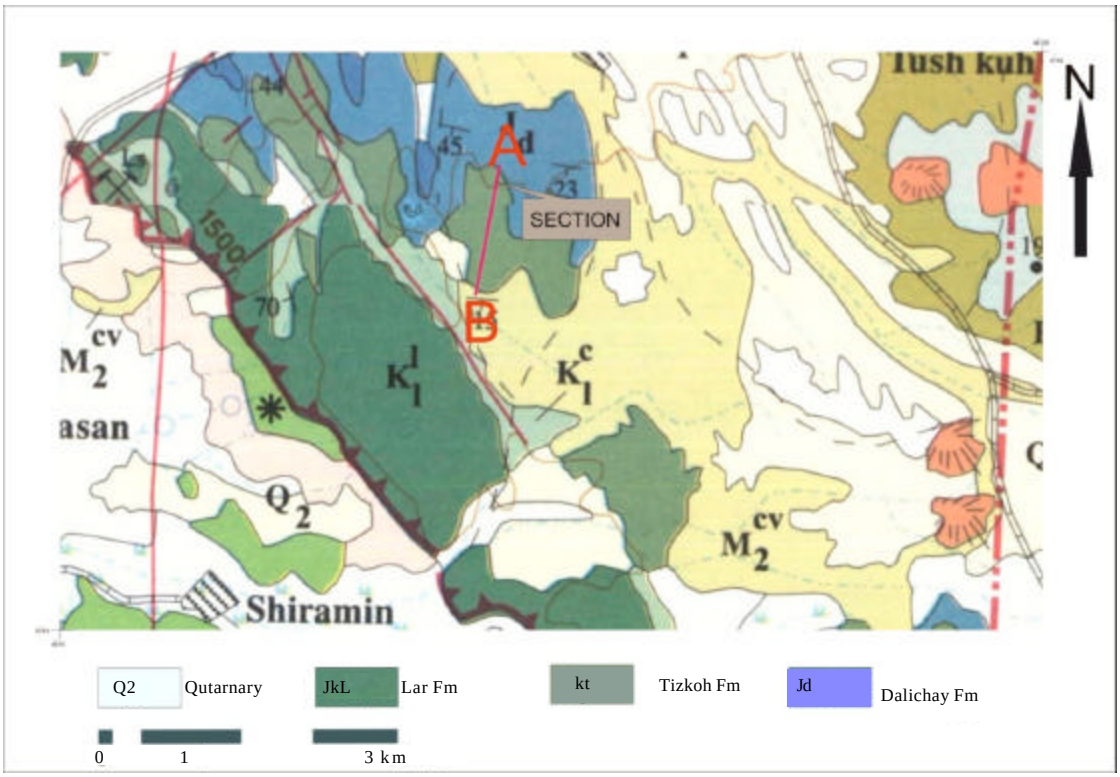

Fig. 2: Geological map of study area (Khodabandeh and Aminafzal, 1995)

sections were prepared and studied. Ten thin sections was used by Red Alizarin (Red-s) to determine of calcite and dolomite mineral also detection of iron in carbonate cement was paint during burial and then thin sections petrographic of formation carbonate parts were named by Dunham (1962). Finally, carbonate parts microfacies were determined based on Flugel facies belt and the Lar formation deposition environment was determined based on existing facies. Twenty samples for X-ray diffraction (ten samples from the lower marl and ten samples from upper marl) were selected according to the lowest carbonate amount (value). Samples analysis in laboratory was done by Simense-Difractometr 500 device in Geology Organization and Mineral Exploration of Tabriz.

RESULTS AND DISCUSSION

Lar formation lithostratigraphy: Lar formation according to late Jurassic age has large out crops in area of the Alborz-Azerbaijan and it has in traduced rich of the Ammonites and Foraminifer. According to present of fossils its age has been determined of Late Jurassic (Oxfordian-Kymbrjyn) (Aghanabbati, 2005).

In field studies, the Lar formation thickness was determined about 250 m. Its lower boundary is located on Delichay formation gradually and it the upper boundary is an erosion unconformable with Tizkoh formation. Lar formation sections are consists of three facies as follows.

The lower marl section thickness is about 70 m. The middle limestone with red marls section thickness are about 80 m. Gray limestone to upper milky section thickness is about 100 m.

Clay minerals: According to the XRD obtained results (Table 1) samples of related to the middle marl, peaks of smectite, illite and chlorite is observed and the lower marls are detect able peaks of smectite, illite and silica (Fig. 3).

As Fig. 3 shows, climate and depth of deposition of smectite in sedimentary environments is directly related to the high level of water, sea water as well as warm and mode rate climates conditions with alternating grey and wet seasons that it changes frequently. Also, chlorite and illite with origin of detrimental is formed in low leaching condition and weathering in cold and temperate climate or cold and dry rarely. Adatte *et al*. (2002) believes that the simultaneous presence of the smectite and illite in the depositional environment may be representing of sediments in temperate climates.

According to this simultaneous presence of the smectite minerals in the lower marl Lar formation can be concluded that the early Jurassic period is low to mode rate leaching amount

Table 1: Amount of clay minerals in removal samples that represent of smectite relative increasing and relative decreasing of illite toward low of Lar formation

Sample No.	Montmorillonite	Illite	Cholorite
1	75.45	18.02	29.01
2	69.30	21.21	31.02
3	50.23	43.20	35.04
4	49.30	48.02	37.21
5	48.10	55.22	38.20
6	47.00	60.22	39.51
7	46.90	64.30	39.00
8	46.50	64.60	37.00
9	45.50	64.90	38.90
10	45.20	65.00	40.00
11	43.40	67.00	41.20
12	42.10	67.30	43.00
13	40.00	67.90	42.00
14	35.00	68.20	43.60
15	34.60	68.70	42.30
16	34.20	689.00	44.00
17	34.00	70.00	45.90
18	33.00	74.20	46.90
19	32.60	74.30	47.00
20	31.90	74.60	48.90
21	32.00	73.00	50.60
22	33.10	73.40	53.50
23	34.00	74.00	54.80
24	32.00	71.70	54.90
25	31.00	75.00	55.90
26	29.00	71.00	55.60
27	30.00	76.60	54.80
28	29.00	76.90	56.70
29	28.60	79.90	56.90
30	28.40	79.00	54.00
31	28.00	76.00	70.00
32	27.70	75.00	60.50

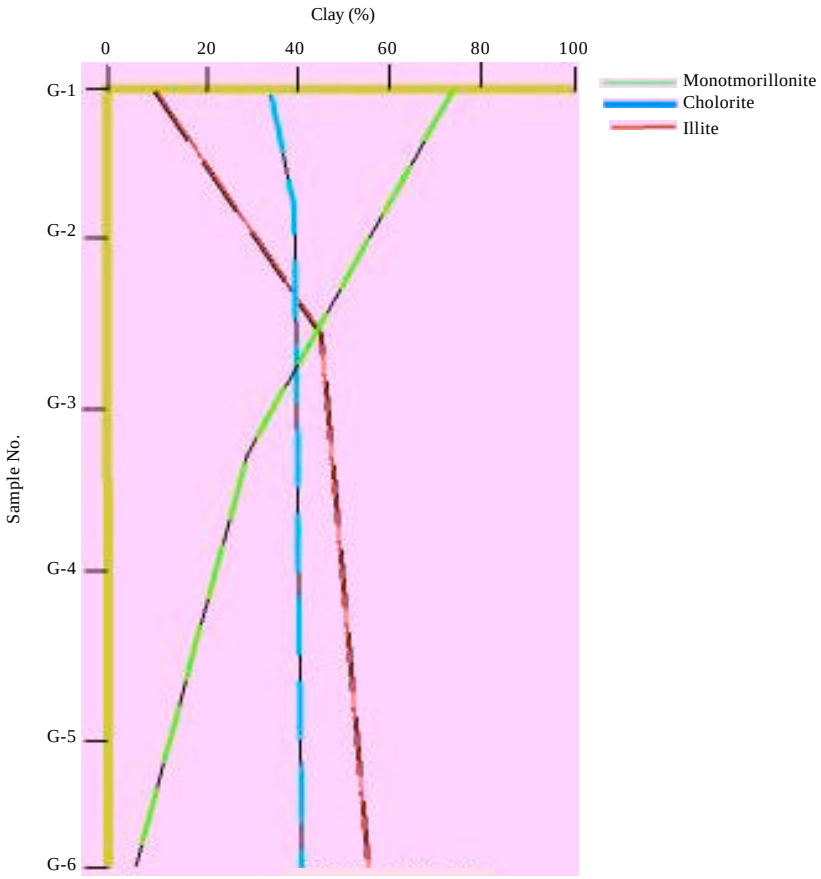

Fig. 3: Semi-quantitative analysis of the clay minerals in Lar formation

(value) and the weather is warm and humid (Mees *et al*., 2007). Smectite compared with illite and chlorite deposits in the deeper parts of the bas in in which sediment action environment (Adatte *et al*., 2002).

According to smectite decreased and illite relative increase the upwards parts sedimentary basins in studied section, it can be concluded that the depth of the sedimentary basin has decreased upward parts of the formation (Stuben *et al*., 2002). The high rate (amount) of smectite in the lower part of the Lar formation in studied section can be attributed to uplifting sea water level in the early Jurassic period (Razmara, 2005). This issue is confirmed by considering of the global and regional changes of sea water level (Vail *et al*., 1977).

Microfacies: Main components Lar formation deposits can be classified in the two components of the non-carbonate and carbonate. The most important carbonate allochemes in thin section of study identified bioclasts the type of planktonic foraminifera.

The non-carbonate components Lar formation can be pointed to detrimental quartz, charted iron oxide which detrimental quartz particles is observed in the lower marl and iron oxide, chert nodules are observed in limestone upper and low part. According to components type and quantify were identified three microfacies of bioclastic packstone, bioclastic wackstone and mudstone.

Bioclastic packstone: Components of Bioclastic dominant skeletal in this microfacies is type of planktonic foraminifers which they are in a micrite matrix. This microfacies is observed in the upper part of the formation. There are others bioclastics in this microfacies that maybe pointed to parts of the Ammonites. This microfacies is equivalent to facies of No. 2 (RMF2) infacies belts Flugel (Flugel, 2010) which represents the least deep of Lar formation part (Fig. 4a).

Bioclastic wackstone: This microfacies allocates 20% of bioclastics (planktonic foraminifera predominantly) that it is a micrite matrix. The planktonic foraminifera in this microfacies can be pointed to milolida and the non-carbonate components in this facies can be pointed to chert fragments. This microfacies is observed mainly in the middle and upper Lar formation. This microfacies is equivalent to facies of No. 3 (RMF3) in facies belts Flugel (Fig. 4b).

Mudstone: Bioclastics is less than 10% of the sample volume in this microfacies and it has a floating micrite matrix. Over all, this microfacies makes the deepest of formation carbonate part.

Limited bioclastics facies in this microfacies are include of planktonic foraminifera and there are rich ammonite facies within the Marl. This microfacies is equivalent to facies of No. 3 (RMF3) in facies belts Flugel (Fig. 4c).

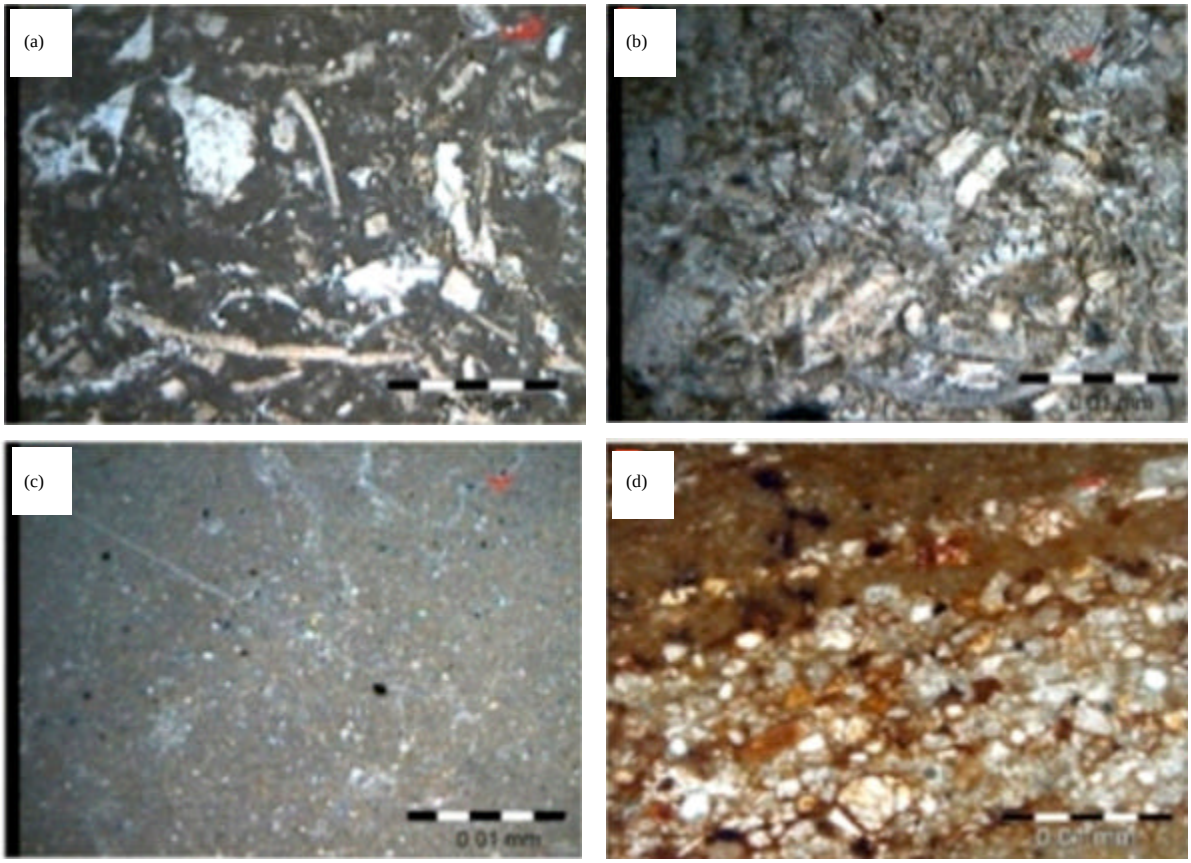

Fig. 4(a-d): (a) Bioclastic wackstone, (b) Bioclastic packstone, (c) Mudstone and (d) Iron oxide of developing into fractures that it is the latest

Depositional environment: According to the evidence of petrography and facies and clay minerals studies of the Lar formation marl part has deposited in the open marine and carbonate platform.

According to the Lar formation in the study area is located between two Tizkoh and Delichay formations (Berberian and King, 1981) and it's also important to remember that both are introduced in the western Alborz region with an open marine and carbonate ramp (Aghanabbati, 2005). The Lar formation deposition in the study area can be called related to an open marine and carbonate platform that its schematic model is shown in Fig. 5. Based on Flugel facies, facies of

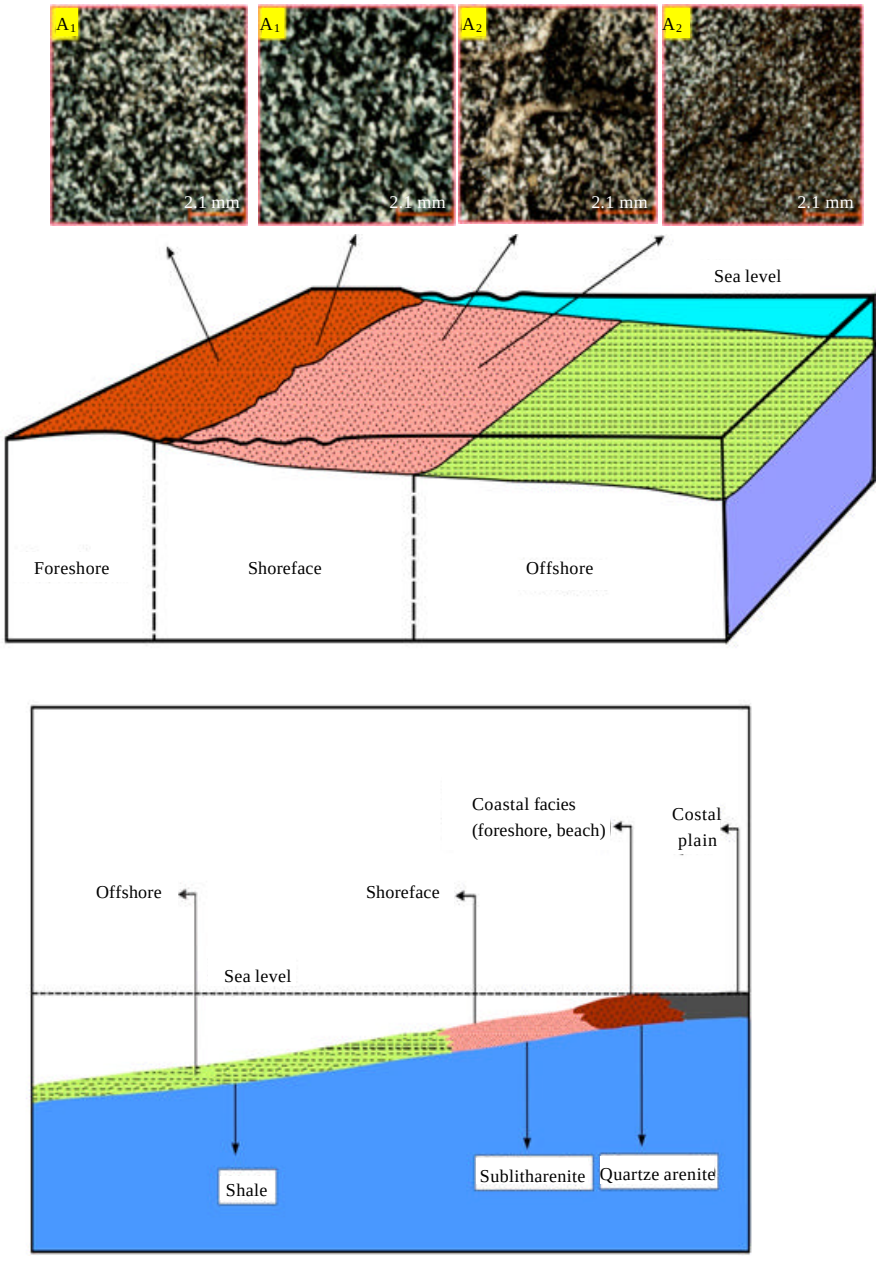

Fig. 5: Lar formation depositional environment model in area study

No. 2 is represents the deposition of the formation in the middle and interior ramp and open marine basin part. Facies of No. 3 is related to the middle and outer ramp from carbonate ramp. Deposits of this formation have been in traduced in Kopetdagh (Mozdoran formation) as a carbonate ramp (Adabi and Rao, 1991).

Diagenesis: Diagenetic processes of a limited is done because of semi-deep of Lar formation deposition bas in that it is based on event includes.

The cement action which is consist of equal calcite cement at ion veincalcite cementation, dissolution and porosity of the inter-granular fracture and channel, finally processing of iron stain into the fractures chert nodules formation.

Studies of sections shows which processor being is occurred in the study area and also it has been filled in to the fractures (Fig. 6).

The others of digenetic processes are including the primary and secondary porosities. An inter-granular porosity is the types of primary porosity that generally, it has been filled by cement and in the case of; also, shelter porosity is observed (Hardy and Tucker, 2004).

Porosity due to fracture in the late diagenetic stage (Late diagenesis) occurred in the dissolution process can cause it spread and cause to be channel porosity that this process is observed clearly. Finally, it should be noted that the Lar formation is having ferro occurrence in the late condition. The process considering to filling the fractures with constructing of chert nodules is last diagenetic processes (Grassman and Milet, 1961).

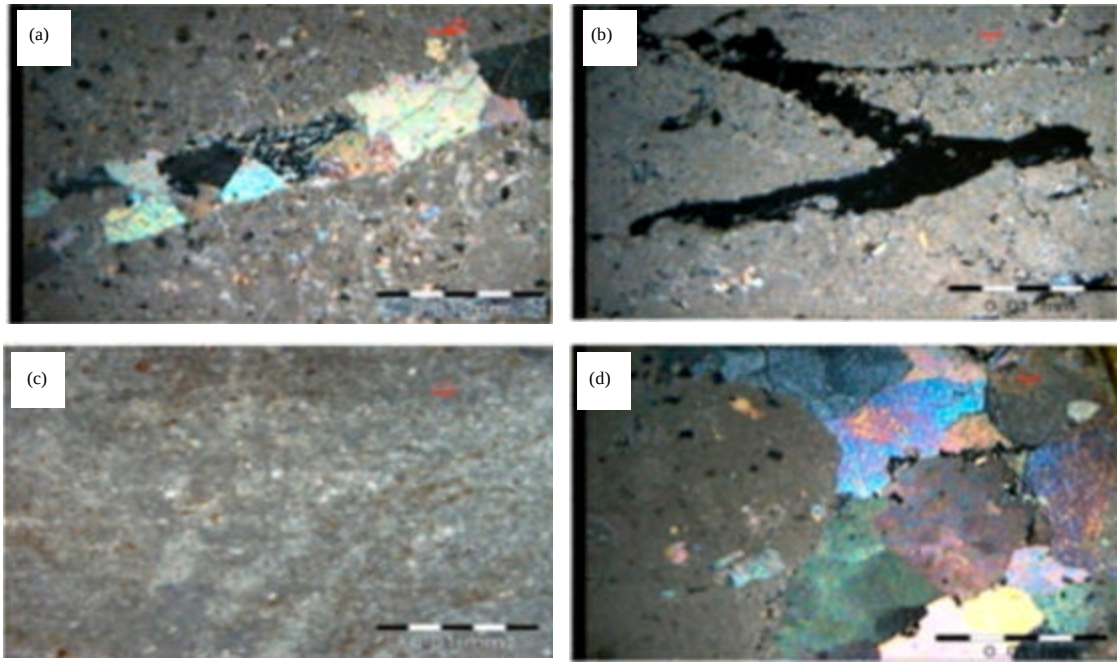

Fig. 6(a-d): Lar formation diagenetic events, (a) Cementation into fractures, (b) Channel fractures that it is caused of permeability increasing, (c) Diagenetic step iron oxide of developing in to fractures that it is the latest and (d) Equalcalcite cementation that it has been advanced into fracture

According to the presence of illite, chlorite, smectite with detrital origin in the samples can be identified constructing of alogenic smectite related to change and con version of others clay minerals.

CONCLUSION

According to study on microscopic thin sections showed that Lar formation has three microfacies of bioclastic including the packstone, wackstone and mudstone which representing of deposition in the middle part of this formation, as well as it is an open marine of carbonate ramp typein sedimentary basin of Alborz-Azarbaijan.

The survey of clay minerals showed due to presence to smectite and cholorite as well as probability of alogenic smectite in this formation and their changes upward are representing the decrease of depth and climate warming.

Diagenetic processes that it is observed in the Lar formation sequence of events including: the cementation (equal calcite cement and a vein cement calcite), the appearance of chert nodules in fluencing of environment changes, dissolution and appearance of porosities of the inter-granular, middle-granular and shelter fracture, finally, the process of ferro occurred within the fractures. To sum up these fractures have prepared the suitable groundwater aquifer in area of study.

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