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Lithogeochemistry of Fatha Formation in Selected Setions-Northenr Iraq

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Abstract

A total of 52 samples collected from marl, limestone and gypsum lithological units of Fat'ha Formation (Middle Miocene). These samples were firstly chemically analysed for; SiO_2, Al_2O_3, TiO_2 ,CaO, MgO, Na_2O, K_2O, Fe_2O_3, SO_3, Mn, Co, Ni. Pb, Zn, and Cu, then mineralgically analyzed via x-ray technique. Insoluble contents were also determined. Mineralogical investigation showed the mineral assemblages are as follow; gypsum, calcite and dolomite, feldspar, and quartz. Clay minerals composed of illite, palygorskite, kaolinite, chlorite, montmorillonite, and chlorite-montmorillonite mixed layered in variable proportions. Distribution of minor elements in Fat'ha lithological units are govern by their geochemical affinitites and mineralogy. The main diagenetic processes affecting the studied rocks were found to be anhydrite hydration, recrystallization and dolomitization. Moreover , diagenetic processes lead to changing the major and trace elements concentration due to remobilization of these elements during that processes. The vertical distribution pattern of clay minerals suggests fluctuation in the salinity and detrital supply of terrigenous materials throughout the deposition of Fat'ha Formation

Introduction

Geochemistry of sedimentary rocks may complement the petrographuc data, especially when the latter are ambiguous. The geochemical composition of sedimentary rocks is a complex function of various variables such as source material, weathering, transportion, physical sorting, and diagenesis (Middleton 1960, Piper, 1974, Bhatia 1983, Mclennan 1989; Cox and Lowe 1995 cited in Armistrong-Altrin *et al.*, 2004)

Together with the carbonate rocks, evaporites form large part of sedimentary column. Mason 1966 states that evaporites are highly significant in the interpretation of geological history. In general Evaporites formed as a result of drying up of the sea water which trapped in shallow restricted basins.

Evaporites in Iraq has been deposited mainly during two main ages: Jurassic (Qutnia Formation) and Miocene (Dhiban Formation- Lower Miocene and Fat'ha Formation- Middle Miocene) (Al-Sinawi and Saadallah, 1971)(Fig 1).

Fat'ha Formation (Formerly Lower Fars) (Middle Miocene) represents the most conspicuous and the main gypsum bearing formation within Iraqi territories as well. Based on some invertebrate fossils the age of Fat'ha Formation is determined to Middle Miocene (Van Bellen *et al.*,1959; Buday, 1980, and Jassim and Goff, 2006). All the workers who have studied Fat'ha Formation agree that it has been deposited under marine environment according to the fossil content and lithofacies characteristics. Lithologically, Fat'ha Formation consists of alternating cycles of gypsum, marl, and carbonates. Furthermore, this formation generally characterized by its wide geographic distribution, it is extent from southwest Iran across Iraq to northeast Syria (Fig, 2). Dunnington (1958), Gill and Ala (1972), Al-Marsoumi,(1980), Mustafa, (1980), and Jassim and Goff, (2006), suggested a lagoonal environment for the deposition of Fat'ha sediments. On the other hand Al-Hashimi, (1979, in Mustafa, 1980), and Buday (1980) showed that Fat'ha Formation laid down in an elongated semiclosed basin of regional extent developed under semi-arid conditions, with it's axis running northwest-southeast. Moreover, this formation exhibits different thickness from one place to another, for instance, its thickness at sheikh Ibrahim (35 km west of Mosul city) is 310 m, whereas its thickness reach 105 m at Ain Al-Safra. This variation in thickness within this short distance might be the result of the different mobility in the basement blocks (Al-Rawi and Amin, 1979)

Fat'ha Formation bears an outstanding important economic value; it forms the cap rocks of many Iraqi oil fields, furthermore, also it could form a good reserve for native sulphur production via the extensive reduction of its sulphates members (e.g. Mushraq sulphur mine northern Iraq). These rocks also can be used in building industry either as ornamentation stones or to produce building plaster (locally called Juse) (Mustafa, 1980, and Alkufaishi and Al-Marsoumi, 1988). Moreover, Fatha Formation form a good reflectaness surface in geophysical investigations (Al-Sayab *et al.*, 1982). It is worth to be mentioned that Gachsaran Formation of south west Iran is equivalent to Fat'ha Formations(Jassim and Goff, 2006). From stratigraphic point of view, Fat'ha Formation is disconformably underlain by Euphtrates/Jerbi Formations

(Lower Miocene), and conformably overlain by Injana Formation (Upper Miocene) (fig.3).

The prime purpose of this work is to study the geochemical behaviours and characteristics of selected major and trace components of the Fat'ha Formation lithological units, to increase our understanding of the environment of deposition of these units, and the environmental factors as well as, the postdepositional changes that acted on them.

Methodology;

Three surface sections were selected from Sheikh Ibrahim , Ain Al-Safra and Kand area in an attempt to study the geochemical and petrological aspects of Fat'ha Formation. A total of 52 samples were selected from different lithological units of Fat'ha Formation in the selected sections (Table,1). The distribution of selected samples from each section is uneven dependent on the availability of outcrops. The petrographycal characteristics of Fat'ha Formation gypsum rocks was given by Al-Marsoumi (1980), whereas the other two lithological units were illustrated by Al-Bayati, (2007). The collected samples were analyzed for the following components; Mn, Co, Ni, Pb, SiO_2, Al_2O_3, TiO_2 at the lab of Geosurv, Baghdad, CaO, MgO, Na2O, K2O, Basrah University Lab, as well as Fe_2O_3, SO_3, Zn, and Cu (Petroch. Indust. Basrah). Unfortunately due to technical difficulties Sr can't measured, thus to overcome such problem the Sr data was abstracted from Al-Marsoumi (1980) and re-discussed in this study..

Insoluble Residue (I.R) and Loss On Ignition (L.O.I) within the carbonate rock unit were determined. Following the method suggested by Hutchinson (1974), and Lechler and Desilets, (1987). It is worth to mentioned that the Injana Formation was include in I.R. in this Study for the completion of the Middle Miocene-Upper Miocene sedimentary cycle.

To insure the reproducibility of the analytical data, the precision of chemical analyses were checked following the method of Rose et al.(1979, Maxwell, (1968), and Stanton (1966) which are within the acceptable value and the applied methods were at high analytical accuracy (1-2%)(table, 2). To facilitate interpretation of the raw geochemical data, trend analysis statistical technique were employed based on the statistical program mintab II.

The clay fractions was separated according to the pipette method suggested by Folk (1974). The oriented slides from each sample were prepared according following Method of Gipson; (1966). Then x-rayed diffraction technique employed (XRD) using Cu-K radiation as follows: as it was initially prepared, following glycolation for 24 hours in an oven at 60˚ C , and after heating to 550˚ C for two hours. Furthermore, the bulk samples were also examined by XRD. The traces of detrital impurities occurs as quartz mineral was detected. The scarcity and very fine grained of celestite, bassanite, dolomite, and quartz make them not to be observed in thin sections, but documented by x-ray technique.

To facilitate the interpretation of the raw data trend surface and and autocorrelation analyses was employed following the programs suggested by Davis (1973).

Mineralogy:

The microscopic examination besides the XRD test revealed the occurrances of different mineral species which could categorized into three groups:

1-Carbonate minerals; The XRD diffractograms (Fig, 4) depict the occurrences of the following minerals according to their abundance; High-Mg-Calcite (HMC), Low Mg-Calcite (LMC). And dolomite.

2-Sulphate minerals; The mineralogical analyses of evaporites rocks under study confirm the presence of gypsum as a major mineral with subordinate amounts of celestite, bassinate (transitional phase of anhydrite to gypsum), dolomite, with relicts of anhydrite which is believed to be inherited from pre-existing anhydrite beds. With traces of detrital quartz (Fig,5). A plausible explanation for the presence of Dolomite is due to dolomitization of secondary calcium carbonate precipitated within gypsum beds (Sulayman, 1990 cited in Al-Jubouri and Sulayman, 1996).

3-The soluble part of the marl (the carbonate) has been dissolved away and redeposited mainly as dolomite within calcium sulphates during diagenesis (Al-Jubouri and Sulayman, 1996). Whereas the clastic part occurs in form of clay mineral; illite, palygoriskite, kaolinite, chlorite montmorillonite, and chloride-montmorillonite mixed- layered.

Kaolinite within Fat'ha Formation is usually of detrital origin, whereas illite may be of detrital or diagenetic origin (Pettijohn, 1975); montmorillonite on the other hand, could be the result of illite transformation of smectite in soils and subsequent transportation to marine basins (Flugel, 1982). Palygorskite is of diagenetic origin, because such mineral cant survive long period of river transportation, and the availability of arid climate, hypersaline, alkaline medium, and Mg-rich environments may induce the palygorskite formation (Al-Marsoumi *et al*.,2006). On the other hand, under the condition of high salinity, high pH, the availability of magnesium accelerate the alteration of montmorillonite into palygoriskite (

Albadran and Hassan, 2003).The montmorillonite-chlorite mixed layered represents an intermediate stage of clay mineral alteration, a similar result was reported by Chamly (1989) who attributed this phenomenon to the diagenetic formation of chlorite in shallow marine to brackish environments.

The vertical distribution of clay mineral species illustrated in Fig,(6). Illite + palygorskite reveal a very outstanding increasing upward, which possibly refers to alternating periods of closing and increasing salinity followed by a period of opening of depositional basin salinity and increasing of detrital clay mineral influx. The reverse view exhibits in Kand and Ain Al-Safra sections. The pattern of Chlorite. – Montmorillonite distribution in the studied sections, suggest that diagenetic intensity of clay mineral alteration upward decreasing and increasing in Kand, Ain Al-Safra, and Sheikh Ibrahim section respectively. The high amount of Kaolinite in Kand and Sheikh Ibrahim section indicates the closeness of these two sections to the paleoshore line in comparision relative Sheikh Ibrahim section.

Depending on the results of X-ray diffraction, kaolinite, illite, palygorskite, montmorilonite, and chlorite are the main clay mineral types. Most of the identified detrital clay minerals represent the weathering product of different source rocks such as basic and few acidic igneous, and metamorphic rocks.

Insoluble Residue (I.R);

Owing to pettijohn (1975), neither halite, nor gypsum or anhydrite if found in nature in state of absolute purity. Study of the water – insoluble residues of salt deposits shed light on their minor constituents. The insoluble residue represents all the materials remains after treating the sample with a dilute acid. Furthermore, The study of I.R contents assumed to be a complementary to the petrographic researches. Table (3) shows ranges and means of the I.R contents within the rock samples under study. All the lithological units of Fat'ha Formation within the studied sections contains various percentage of I.R. . The amount of I.R. increases from Sheikh Ibrahim toward Ain Al-Safra approach Kand section, this result proved that the direction of rivers which contribute clastic sediments toward Fat'ha Formation deposition basin drain from northeast to southwest i.e. from the high folded and thrusted zone toward the foothill of the folded zone (Fig, 6 A, B, C) The I.R. within gypsum rocks refers to the mixing of the fresh influx contributed by rivers with sea water, then the subsequent evaporation leading to the deposition of gypsum enriched with clastic sediments (marly gypsum).

Geochemistry;

Geochemical criteria were used in various ways as to record the characteristics of different types of sedimentary rocks, and to delineate the physio- chemical changes which leave their prints on the sedimentary rocks. The major elements concentrations of all Fat'ha Formation samples are arranged in Table(2). The chemical composition of Iraqi and international carbonate, gypsum and marl is shown in table (6 A, B).

The average concentration of Ca and Si in sea water are $4x10^{5}$ and $3x10^{3}$ ppb respectively (Faure,1998). These two elements involved in biological cycle, therefore, their concentrations fluctuated from place to another and with the depth of the ocean basin (Mason and Moore, 1982). Calcium is one of the major elements in the studied rocks. Its content ranges from (27-56%)in carbonate, (4.66-48.72%) in gypsum, and (4.16-44.92%) in marl. The concentration of calcium in Sheikh Ibrahim are close to that of Kand section and both of them are higher than that of Ain Al-Safra. which is possibly related to the dominancy of alluvial factors in clastic material contribution and sea water dilution i.e. diminishing of chemical precipitation. Gypsum rocks exhibit wide range of calcium contents, owing to Al-Bayati (2007), this fact could be attributed to the syndepositional interferences of clastic and chemical factors which took place as a result of alternating opening and closing of depositional basin. Regarding marl; green marl shows higher and lower concentration. of Ca in Sheikh Ibrahim in comparision with that of Ain al-Safra, whereas, the intermediate value recorded in Kand area. The lateral variation of Ca concentration is attributed mainly to variation in intensity of chemical precipitation among the studied sections. This coupled with the tendency of green marl to connect with carbonate minerals more that of red marl as explained by Al-jubori (2005).

Magnesium exhibits a wide distribution in the lithological units under investigation. There is no remarkable difference in the Mg content within the carbonate rocks of the selected sections, this phenomenon seems to be primarily related to the diagenetic processes mainly dolomitization i.e. these carbonate rocks survive the same degree of dolomitization. More over dolomitization regulate the concentrations of Ca and Mg in the present carbonate rocks. Magnesium concentration in sea water is 0.13% (Goldschmidt,1958).therefore, the high concentration of Mg in the studied rocks are attributed to the diagenetic processes and the salinity of the sea water. The Mg contents In the present carbonate rocks is approximately equal to that internationally reported (Table,6B).gypsum rocks exhibit high Mg contents which is most probably related to the salinity of the depositional basin besides. Magnesium is unequally shared between red and green marl (Table, 6A), which could be related to the type and abundance of detected clay minerals. based on the textural characteristics, dolomitization process took place over two stages early and late as illustrated by Al-Asadi, (2002), and Al-Bayati (2007). It is worth to be mentioned that the primary and secondary porosity facilitate the enternace and controlled the extent of dolomitized fluid flow.

Both Silica and aluminum form major and minor constituents of clastic and non-clastic sediments under study respectively. The highest value of Si recorded in the limestones of Ain Al-Safra section in comparison with other two sections. This is believed to be due to firstly crushing of their siliceous faunal assemblages content throughout the diagensis processes , secondly, the high contribution of terrigenous quartz mineral. And thirdly, the closeness of Ain Al-safra section to the shore line . Owing to the close connection of Al with clay mineral chemical compositions, the concentration of this element in the studied lithological units is greatly clay minerals dependent.

Sodium is one of the most abundant alkaline element in sea water, because of its highest mobility in hydrosphere (Mason and Moore,1982; Faure, 1998). This element is widely used as paleosalinity indicator. Based on Al-Kufaishi and Al-Marsoumi, (1988), the differences in sodium content between the non-clastic rocks is most probably due to the paleogeographic position within the basin of deposition, and hence, the degree of evaporation. Moreover the Na contents in gypsum rocks of Sheikh Ibrahim is greater than that of other two sections, which refers to the increasing of Na contents approach the basin centre. Generally speaking the green marl posses high Na contents than that red one. The present mean value of Na is greater than that reported for carbonate (0.54%) (Mason and Moore.1982). It could be concluded, therefore, the studied carbonate rocks laid down in a hypersaline environment.

Potassium represents the second alkaline element after sodium, due to very high solubility of potassium mineral, no mineral of its own is observed within the study area. The main sources of K in the present sediments are clay minerals mainly illite, which detected in x-ray diffractograms (Fig, 6), since K occurs in noticeable amounts in this mineral 7.74% (Grim, 1968, cited in Qazaz and Hashad, 2000). The concentration of K in Ain Al-safra and Kand - sections red and green marls is approximately the same, and both of them are lesser than that of Sheikh Ibrahim. This could be related to the variation of clay mineral contents.

Iron within the gypsum and limestones is mainly associated with the I.R contents, since most of iron transported in the aqueous environment is carried as iron-oxide coating and adsorbed on detrital mineral grains(Berner,1971, cited in Al-Marsoumi and Al-Hamadani, 2001). Insoluble residue contents decreases toward Sheikh Ibrahim section, therefore, the Fe contents within Sheikh Ibrahim rocks are lesser than that reported in other two sections and the value reported by other authors(Table, 6A). The abundance of red and green marls is a function of the oxidation-reduction potential of the depositional environment (Al-Joboury, 2005). Owing to Al-Bayati (2007), the similarity and dissimilarity in Fe contents among the studied sections related firstly to the location of the studied section relative to the basin of deposition, and to oxidation-reduction potential of the depositional environments.

Most of titanium occurs in form of titinate, which is identified in Kand section by Al-Rashidi (2005). Titanium is associated with clay mineral which form the bulk of I.R. within the non-clastic rocks under study. The studied carbonate rocks exhibit higher concentration of Ti than that documented domestically and abroad. On the other hand, the marls of the studied sections exhibit low Ti concentrations than that of the published data (Table, 6 A).

Trace elements

Despite the low content of trace elements in sedimentary rocks they are of great value in studying the conditions of depositional environment and the diagenesis processes. Many trace elements were employed in this study; Mn, Zn,Cu, Ni, Co, and Pb. Trace element concentration of Fat'ha rocks are reported in Table(4 A, B, C). These elements reaveld great variation in their concentration in the different lithological units, which could attributed to the depositional environmental conditions, diagenesis processes, and base exchange.

The Mn content in the studied lithological units is lower than the Mn content in carbonate rocks reported by Mason and Moore, (1982).moreover, the later authors state that the sea water contents of Mn is completely dependent on atmospheric and river fluxes. Ronov and Ermishkina, (cited in Mogharabi 1968) found that MnO content is greater in carbonate rocks formed under humid climate (average = 810 ppm) .than those formed in an arid climate (Average=320 ppm). On the other hand, Shanmugen and Pedict,(1983) agreed with Bencini and Turi (1974) that MnO in sediment increases as water depth increases. The average concentration of Mn in Sheikh Ibrahim, Kand, and Ain Alsafra is 367, 739, and 666 ppm respectively, which means that the carbonate of Sheikh Ibrahim deposited in a shallow depositional basin developed under arid climate with low I.R. contents whereas the other two section deposited in basin surviving intermittent mixing with fresh water rich in suspended clastic suspended load. some of Mn with carbonate unit is related to dolomitization process where Mn^{++} diadochically replace Ca^{++} in the calcite lattice.Al-Mallah and Al-Dabbagh (1998) pointed out that part of Mn in argillaceous rocks of Fat'ha Formation is possibly related to the occurrences of black laminae coating fractures and mud cracks of argillaceous unit of Fat'ha Formation. This black laminae enriched with number of elements namely Fe, Mn, Co, Cu, Ni, and Zn.

Regarding strontium (Sr), the concentration of Sr in evaporites depends mainly on many factors such as paleogeography, position in the stratigraphic column of an evaporite sequence (Rosler,1970), and rock age (Vlasov,1966),…etc. Al-Marsoumi, (1980) found that Fat'ha carbonate rocks shows great variation in Sr concentration (160 and 500ppm), this variation could be attributed to the salinity of depositional basin. The average concentration of Sr in sheikh Ibrahim gypsum rocks is 354 ppm and its range from 82-692 ppm. Which is less than the average concentration of Sr in gypsum and anhydrite (2000 ppm) (Braitsch, 1971, cited in Al-Marsoumi,1980) Based on Al-Kufaishi and Al-Marsoumi (1988) This result possibly due to the hydration process in which anhydrite is transformed to gypsum, some of the Sr in the original anhydrite structure will be expelled.

Zinc (Zn) , shows low concncentration in carbonate rocks, its concentration In present carbonate rocks are approximately the same, and higher than values given by different authors for domestically carbonate rocks (Table, 5). According to Mason, (1966), zinc is mainly associated with clay minerals, i.e. its abundance is clay minerals controlled.

The copper (Cu) content in the studied carbonate rocks generally is low, and there are a uniformity in its content within the studied sections, besides it is within the ranges found in common carbonate rocks. Whereas, with some exceptions. The present marls revealed low Cu concentrations in comparison with that reported for common marl (Table, 6 B). This differences is mostly due to variation in degree of Cu adsorption by detrital quartz, clay minerals, and organic matter (Francoids, 1988; Gala'n et al., 2003 cited in Hassan, 2007)

Clastic sediments of Fat'ha Formation seem to be the main host for Ni contents.

This result dictates that most of Ni associates with clay mineral contents either as surface adsorb. On the other hand, Till (1979, cited in Kettaneh and Sadik 1989) proved that Ni and V trace elements can be exist in or on clay minerals and organic matter. There is a similarity in Nickel content among the studied carbonate rocks (ranges from 35-49 ppm), which possibly implies similarity in the depositional conditions, and I.R. and organic matter contents.

It was shown by a number of authors (Goldshmidt, 1958; Turikian and wedepohl,1961, and Al-A'asm, 1976…) that the cobalt content in calcareous and dolomitic rocks is always low. Cobalt content in sedimentary rocks ranges between 20 and 30 ppm (Aubert and Pinta, 1977). The cobalt content in the studied rocks generally is low, and there are a uniformity in its content within limestone, gypsum, and marl (Table, 4).

The lead content in the studied rocks is low. Generally speaking the lead contents in the studied rocks is uniform, based on Assafli (1979), the concentration of Pb increases away from the shore line i.e. toward the depocentre, therefore the present low Pb value could attributed to shallow depositional environment of Fat'ha Formation.

Vertical distribution:

The vertical variation of studied components were processed with aid of statistical treatments trend analysis. The present chemical components exhibit different pattern of distributions (Fig, 7). Concentration of Fe, I.R, Zn, Co, and Ni increases upward. Si, Al, and Ti have similar pattern of distribution as a result of their occurrence in clay minerals. Mg and SO4 vary in reverse way within Sheikh Ibrahim and Ain-Al-Safra section, whereas, in Kand section shows a similar pattern of distribution. No serious change in Ca concentration through out the stratigraphic column at sheikh Ibrahim, whereas this element decreases upward in Kand and Ain-Al-Safra sections. The alkali elements K and Na lack any similarity in the vertical distribution within the studied sections, which reflect the fluctuation in the paleosalinity of sea water. Mn concentration increases upward in both Sheikh Ibrahim and Kand, whereas, it decreases upward in Ain Al-Safra section. Cu concentration decreases upward within Kand and Ain Al-Safra, whereas increases in the same direction within Sheikh Ibrahim section. Finally, Pb shows homogenous distribution within Sheikh Ibrahim and Kand sections but it decreases upward in Ain Al-Safra section.

Conclusion

Fat'ha Formation was laid down in semi closed basin evolved under arid and semi climate. Clastic sediments contributed to the depositional basin is controlled the major and trace components in this formation. Some of the major elements (Ca, and Mg) present in various mineralogical forms. The lower concentration of some trace elements than that of common rocks possibly proved the porous media and open system of diagenetic processes. Moreover, the documented trace element contents could be portioned between clastics and chemical (chemical precipitate minerals) fractions. The fluctuation in the degree of salinity throughout the studied sections possibly reflects the tectonic setting of the studied area, since such property is in close connection with the opening and closing of the depositional basin, which in turn related to the reactivation of the basement fractures and faults during the tectonic build of the study area i.e., the Alpine Orogeny. The relative vertical block movements providing the rhythmicity of sedimentological regime of Fat'ha Formation. Most of I.R. in Fat'ha Formation brought by rivers drain from highly folded and thrusting zone NE Iraq. The diversity of detected clay mineral species suggest that the depositional conditions under which the F'tah Formation has been deposited is not homogenous. On the other hand, the presence of montmorillonite-chlorite mixed layered indicates that the diagentic alteration of clay mineral is still going on. The arid and semi- arid climate causing the high rate of evaporation, consequently high Mg content brine developed, hence, dolomitization process initiated. Regarding the depositional environment of limestone and gypsum, the present study showed that were deposited in shallow, marine, lagoonal environment.

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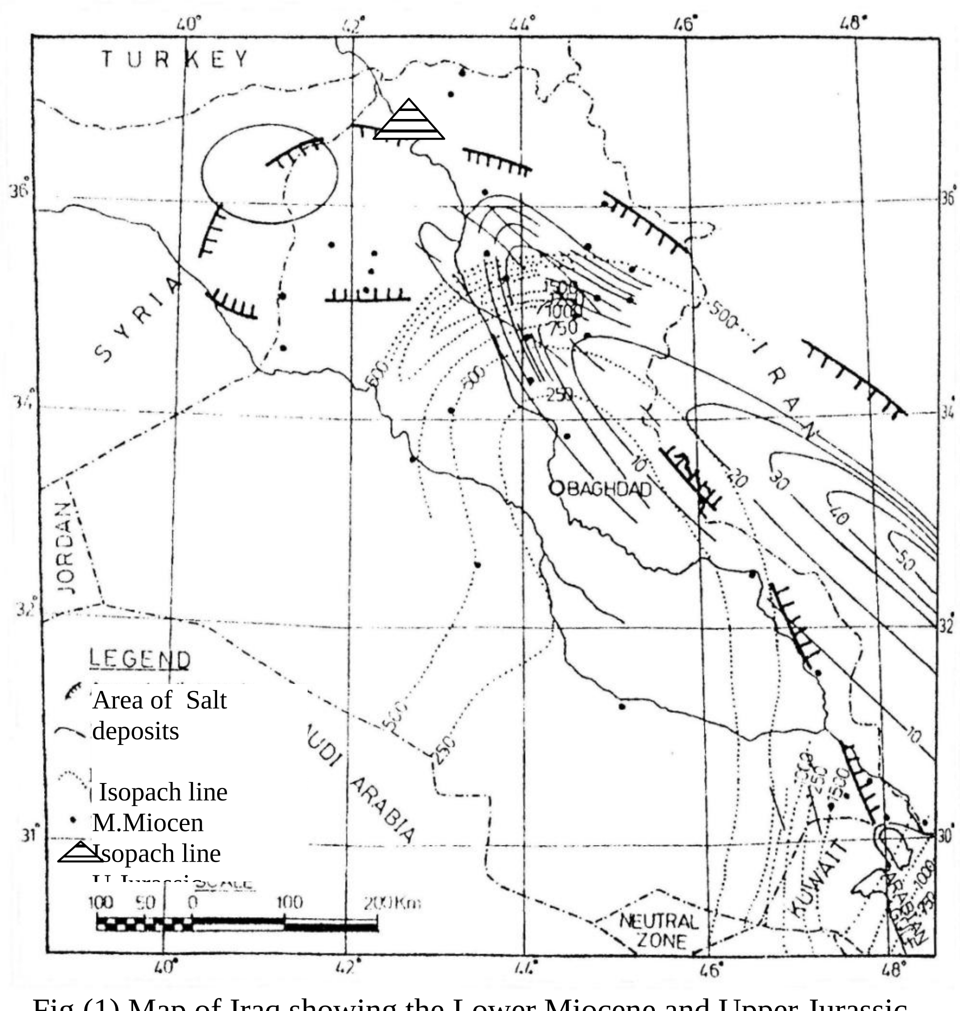

Fig.(1) Map of Iraq showing the Lower Miocene and Upper Jurassic isopachs compared to salt locations (After Al-Sinawi and Saadallah ,1971).

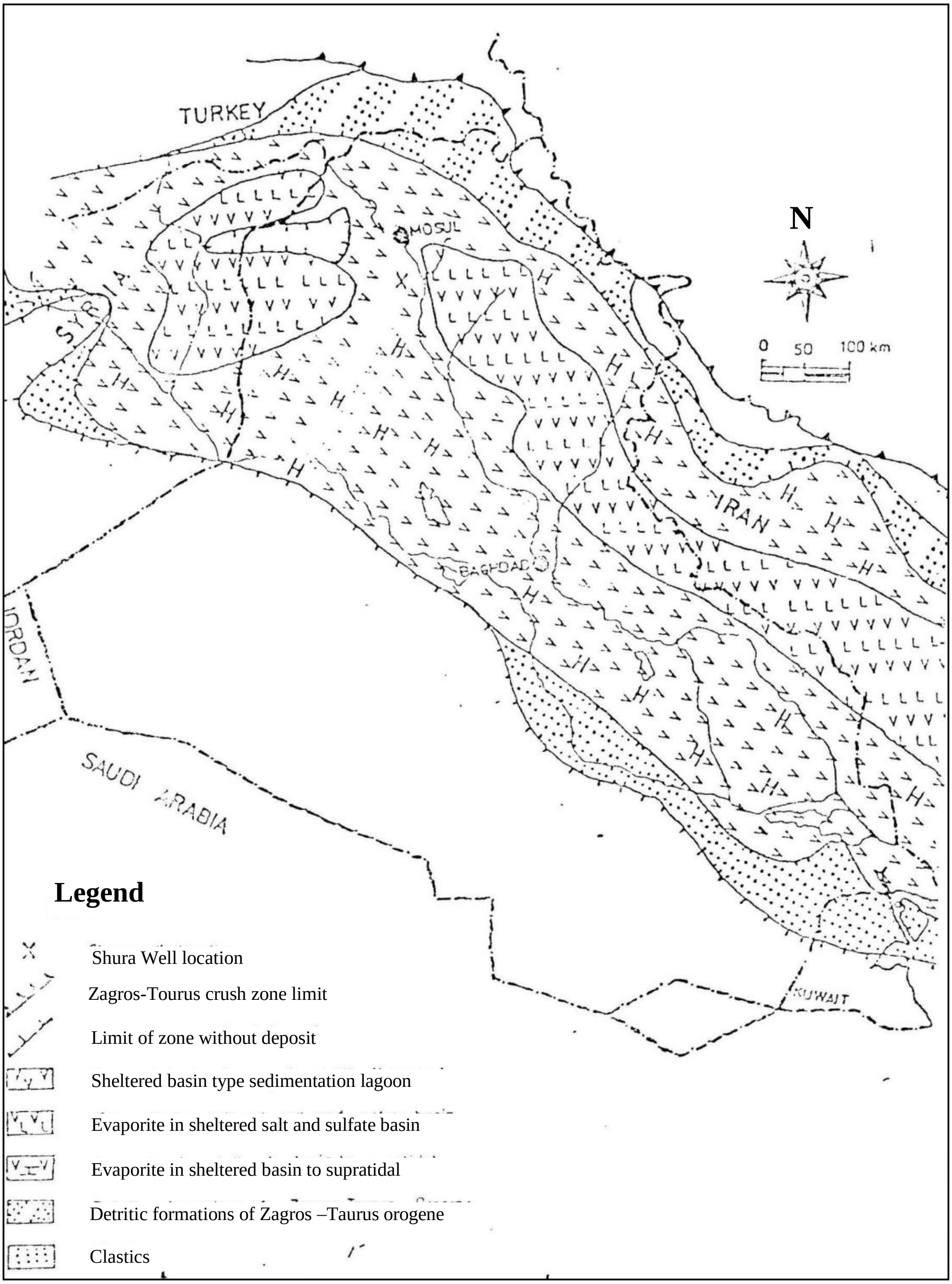

Fig.(2)Lithofacies distribution of Fat'ha Formation (Middle Miocene) in Iraq (after Al-Mashhadani, 1984)

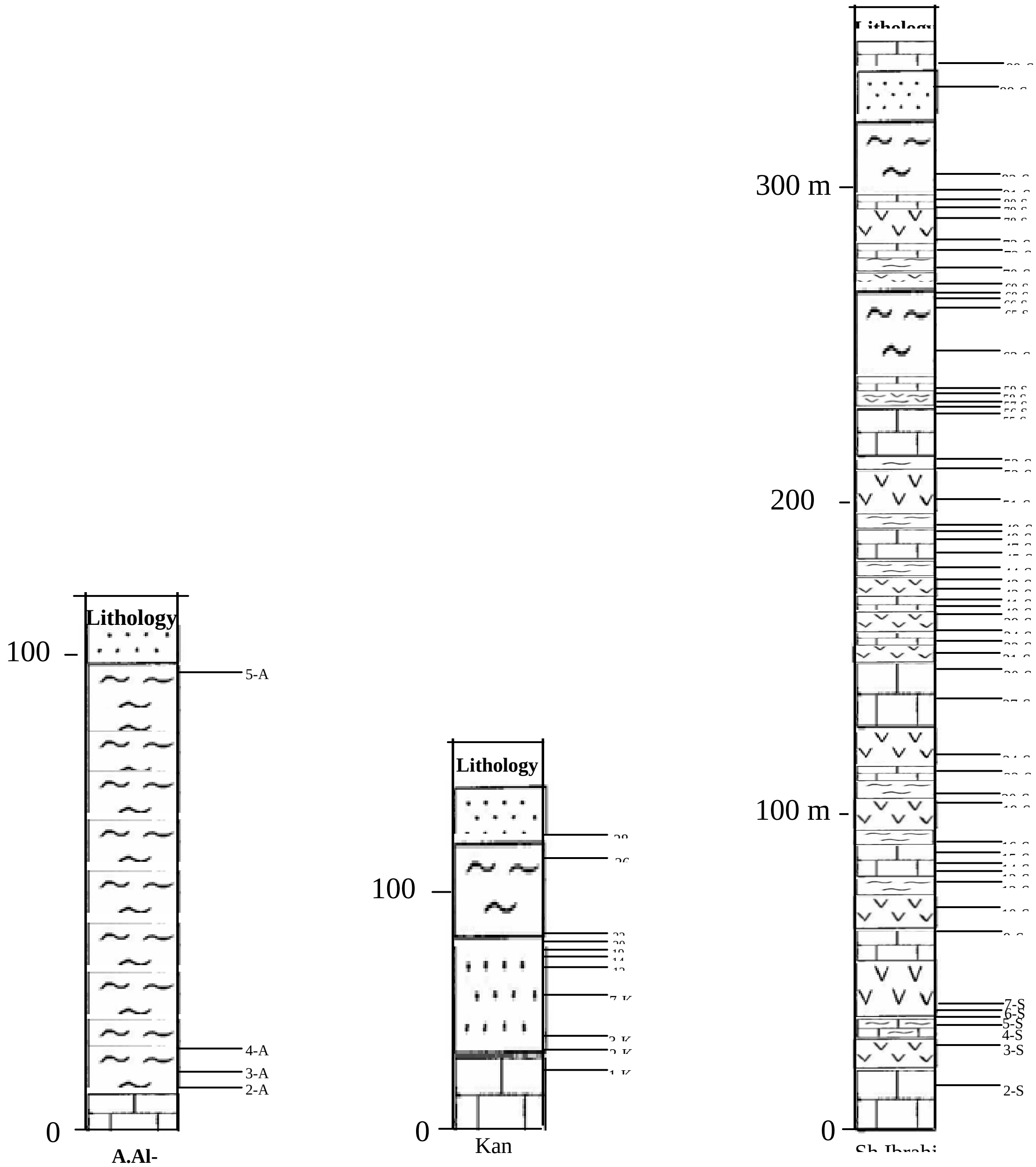

Fig.(3) Stratigraphic column of Fat'ha Formation at Sheikh Ibrahim,Kand and Ain Al-Safra

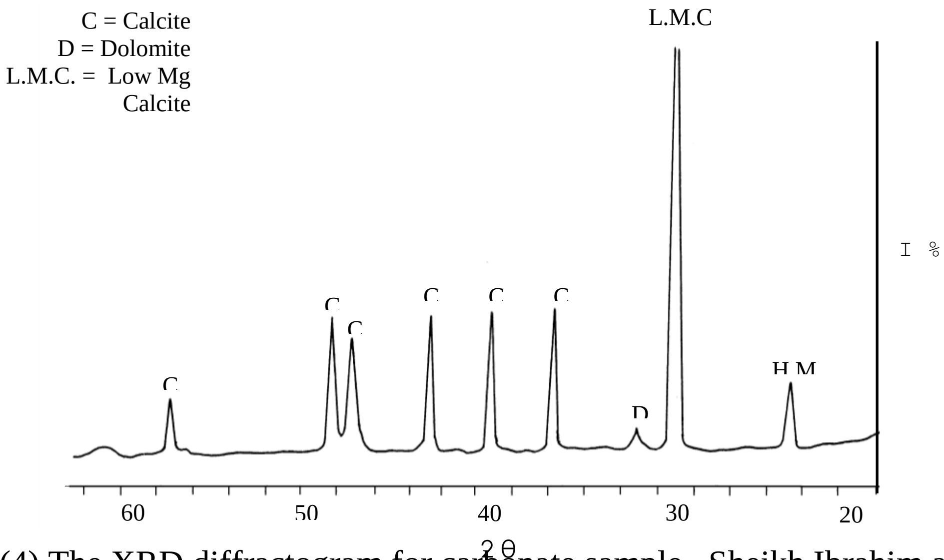

Fig. (4) The XRD diffractogram for carbonate sample –Sheikh Ibrahim area

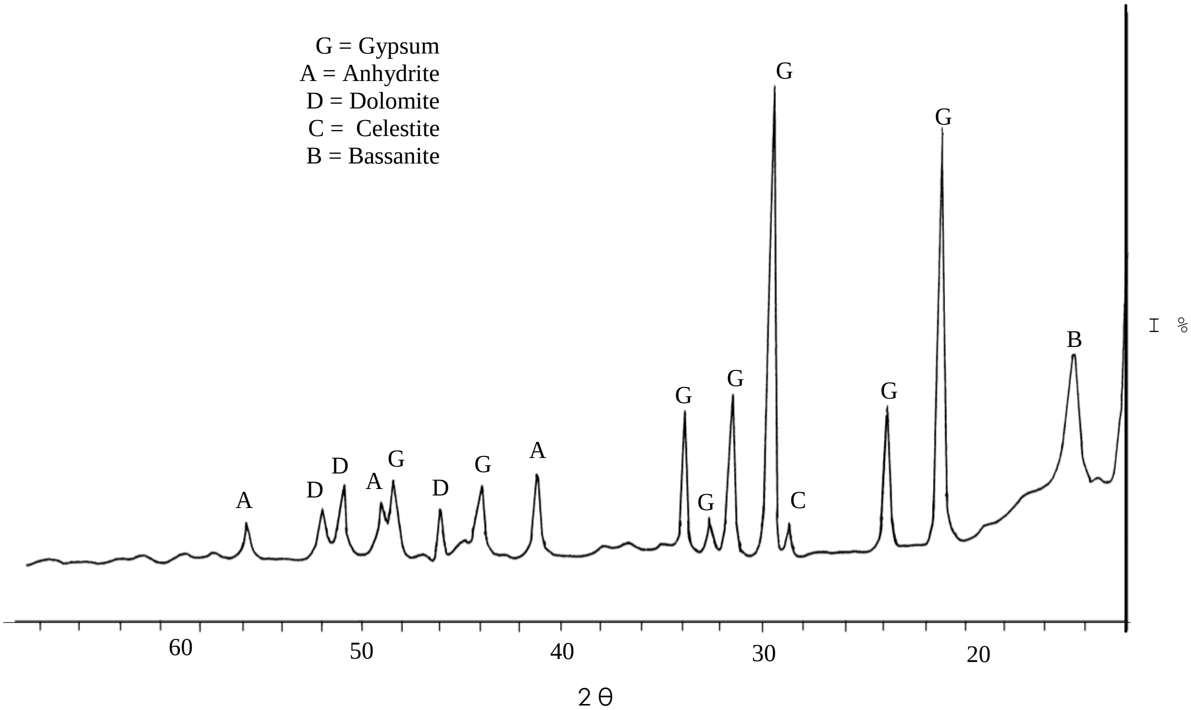

Fig. (5) The XRD diffractogram for gypsum sample –Sheikh Ibrahim area

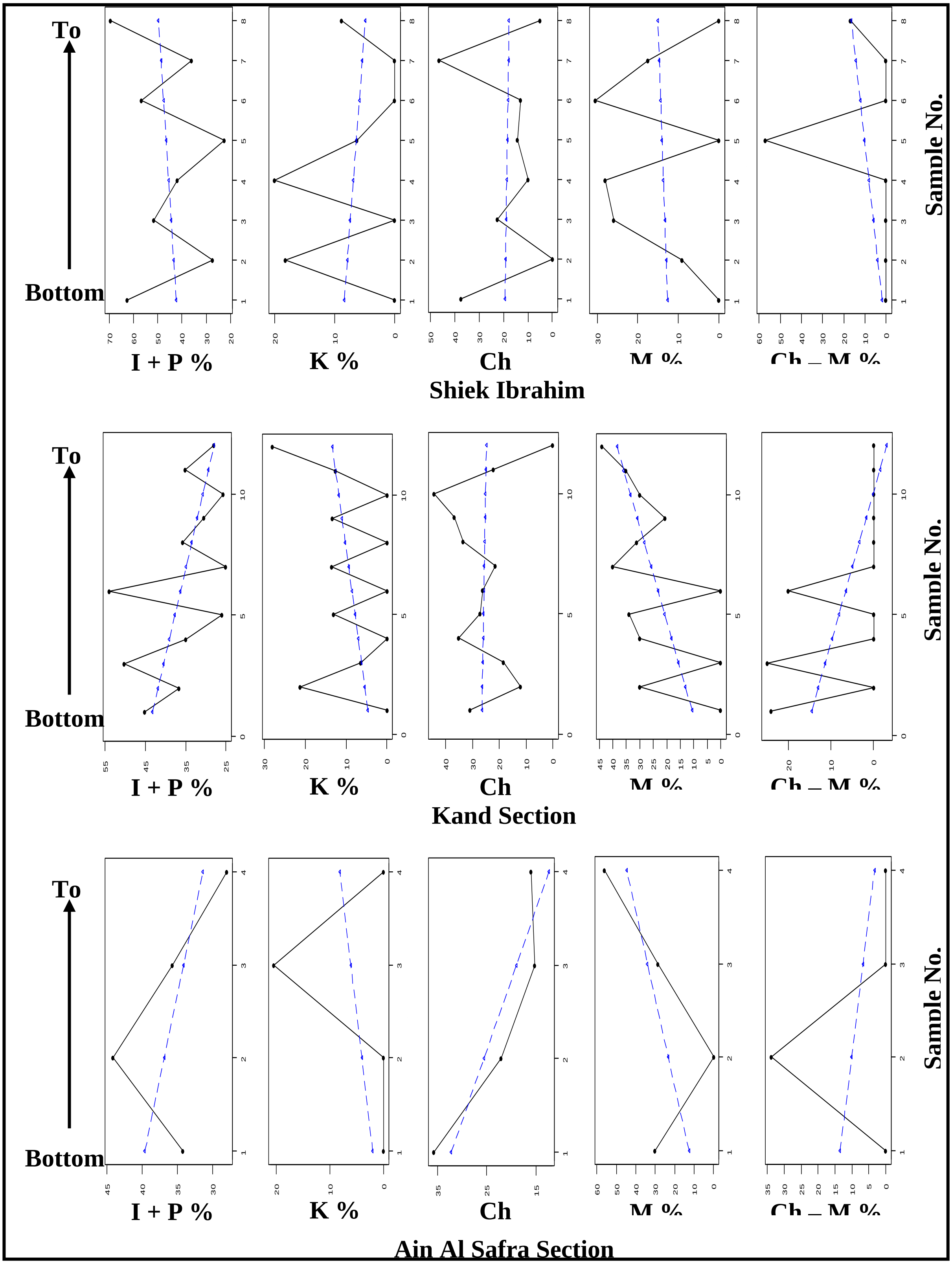

Fig. (6) Trend Analysis of clay minerals identified include studied sections

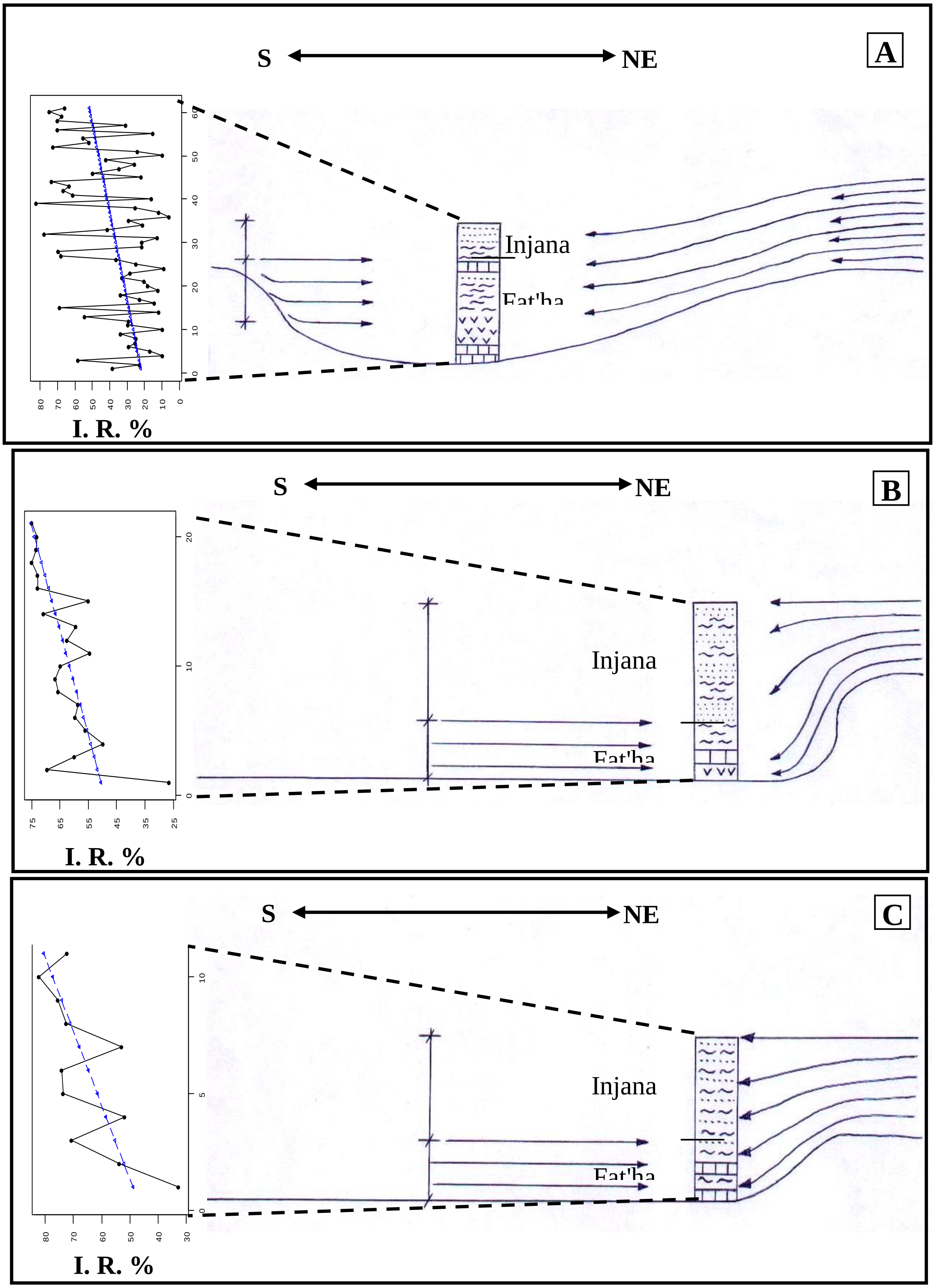

Fig. (7) physiography of Fat'ha depositional at Sheik Ibrahim(A),Ain Al-Safra(B) and Kand (C).

Table (1) Results of accuracy for geochemical data

Element \ Sample No.	1	2	3	4
CaO %	2.52* 2.25**	8.26* 8.02**	20.98* 20.09**	14.77* 14.41**
MgO %	3.83* 3.39**	2.67* 2.90**	8.41* 8.59**	13.49* 12.45**
Na_2O %	2.36* 2.34**	4.15* 4.12 **	1.01* 1.02**	0.71* 0.70**
K_2O %	3.23* 3.25**	4.2* 4.26**	1.4* 1.48**	0.18* 0.196**
Fe_2O_3 %	8.58* 8.31**	6.42* 7.40**	2.16* 2.42**	17.82* 17.12**
Cu (ppm)	-	16.0* 14.0**	-	135.0* 139.0**
Zn (ppm)	-	240.0* 229.0**	-	190.0* 181.0**

* The Value of International publication

** The Value Calculation in present study

1 = international SO-1 standard sample

2 =International SY-3 standard sample

3 =International SO-3 standard sample

4 =International MRG-1 standard

Table (2) Results of precision for geochemical data

Elements	Mean	Standard Deviation	Precision in C.L. 63 %	Precision in C.L. 95%
CaO %	45.2	3.96	8.77	17.53
MgO %	4.82	0.26	5.37	10.74
K_2O %	1.4	0.16	11.29	22.59
Na_2O %	2.2	0.16	7.19	14.37
Fe_2O_3 %	2.7	0.16	5.86	11.71
SO_3 %	0.13	0.016	12.16	24.33

Zn (ppm)	64	3.15	4.92	9.84
Cu (ppm)	33.2	4.15	12.49	24.98

Table (3) Range and Mean of Insoluble Residue in % for studied sections.

Section / Lithology		**Sheik Ibrahim**	**Kand**	**Ain Al Safra**
Limestone	**Mean**	19.98	26.41	32.8
	Range	5.99 - 38.33	-	-
Gypsum	**Mean**	26.56	−	−
	Range	11.70 - 42.12	−	−
Marl	**Mean**	60.63	65.53	52.755
	Range	20.85 - 81.95	64.63 - 66.43	51.74 − 53.77
Sandstone	**Mean**	54.97	59.128	70.69
	Range	-	49.71 - 69.34	-

-A Range and Mean of Trace elements for Fa'tha Formation, Sheik Ibrahim section

		Mn (p.p.m.)	Zn (p.p.m.)	Cu (p.p.m.)	Ni (p.p.m.)	Co (p.p.m.)	Pb (p.p.m.)
S-34S- -59S-	**No.**	**5**	**23**	**23**	**5**	**5**	**5**
	Mean	300.4	80.09	11.52	38	23.8	38.4
	Range	27 – 575	28 – 148	0 – 30	10 – 103	20 – 28	22 – 44
S-42S-	**No.**	**3**	**14**	**14**	**3**	**3**	**3**
	Mean	11	26	3	10	10	10
	Range	9 – 13	18 – 78	0 – 8	10 – 10	10 – 10	10 – 10
-68S-	**No.**	**3**	**10**	**10**	**3**	**3**	**3**
	Mean	278	107	11	56	18	21
	Range	275 – 440	51 – 379	0 – 24	60 – 84	21 – 26	25 – 34
S	**No.**	**6**	**7**	**7**	**6**	**6**	**6**
	Mean	477	106	21	111	22	22
	Range	205 – 863	61 – 248	0 – 31	31 – 174	10 – 33	10 – 25
	No.	**0**	**1**	**1**	**0**	**0**	**0**
	Mean	-	91	25	-	-	-
	Range	-	-	-	-	-	-

Table (4) - B Range and Mean of Trace elements for Fa'tha Formation, Kand section

Lithology	Samples Name		Mn (p.p.m.)	Zn (p.p.m.)	Cu (p.p.m.)	Ni (p.p.m.)	Co (p.p.m.)	Pb (p.p.m.)
Limestone	1K	No.	1	1	1	1	1	1
			850	67	30	49	23	38
			-	-	-	-	-	-
Gypsum	Non							
Green Marl	22K-26K	No.	2	2	2	2	2	2
		Mean	731.5	92.5	130	90	30	29.5
		Range	650 – 813	80 – 105	26 – 234	42 – 138	27 – 33	25 – 34
Mar	Non							

Sandstone	**2K-3K-7K-12K-14K-19K-20K-28K**	**No.**	**7**	**8**	**8**	**7**	**7**	**7**
		Mean	380.13	59.25	126.5	64.133	12.8	12.28
		Range	634 – 990	10 – 88	14 – 410	103 – 167	26 – 29	22 - 34

Table (4) –C Range and Mean of Trace elements for Fa'tha Formation, Ain Al Safra section

Lithology	**Samples Name**		**Mn (p.p.m.)**	**Zn (p.p.m.)**	**Cu (p.p.m.)**	**Ni (p.p.m.)**	**Co (p.p.m.)**	**Pb (p.p.m.)**
Limestone	**2A**	**No.**	**1**	**1**	**1**	**1**	**1**	**1**
			620	66.0	19.0	35	25	44
			-	-	-	-	-	-
Gypsum	**Non**							
Mar n	**3A-5A**	**No.**	**2**	**2**	**2**	**2**	**2**	**2**
		Mean	425.5	84.5	11	92.5	20.5	28

		Range	363 – 488	81 – 88	10 – 12	36 – 149	18 – 23	25 – 31
Red Marl	**4A**	**No.**	**1**	**1**	**1**	**1**	**1**	**1**
		Mean	513	94	12	181	30	25
		Range	-	-	-	-	-	-
Sandstone	**Non**							

Table (5) Ranges of Trace elements for selected Areas from Iraq and the world

Author	**Rock Type**	**Area**	**Mn (p.p.m.)**	**Zn (p.p.m.)**	**Cu (p.p.m.)**	**Ni (p.p.m.)**	**Co (p.p.m.)**	**Pb (p.p.m.)**
A	Gypsum	Sinjar	2					
B	Carbonate	Hit	475	70.6	-	165	-	-
C	Marl	Jabel Ibrahim	-	-	-	110	13	-
D	Marl	Algash Area	325	-	3	327	-	-
E	Argillaceous – Carbonate	Butmah West Area	309	47	19	103	6	8
F	Sandstone	Permam dagh – Erbil	751	39	15	69	21	6
	Mudstone		700	99	36	139	40	13
G	Red Marl	North	-	95.93	39.13	312.6	-	-

	Green Marl	Iraq	-	54.64	41.47	245	-	-
J	Shale	North Iraq	580	95	95	68	19	-
	Sandstone		-	16	-	2	0.3	-
	Carbonate		1100	20	4	20	0.1	-
	Deep Sea Clay		6700	165	250	225	74	-
H	Marl 8616		800	80	57	95	20	20

A- (Saied , 1988)

B- (Al-Kawaz , 1980)

C- (Abdul-Hassan , 1977)

D - (Al- Abaidi , 1984)

E - (Al-Matheedi , 1990)

F- (Al-joboury , 2005)

G- (Turkain and Wedpole , 1961 in Faur , 1998)

H- (Vinogradov, 1962)

Ranges of Major elements for selected areas from Iraq

ea	CaO	MgO	SiO_2	Al_2O_3	K_2O	Na_2O	Fe_2O_3	TiO_2	SO_3
Vest Area	32.22*	0.08*	1028	233	28	90	380	36	45.88*
ul – Ibrahim	31.50*	0.530*	-	-	6	28	2536	-	47.09*
naqin	47.37*	1.09*	-	-	0.11*	0.21*	0.97*	-	-
ajar	32.75*	0.853*	720	44	55	14	56	6	44.99*
it	39.0*	3.48*	14.34*	4.81*	0.93*	0.24*	3.29*	-	0.24*
brahim	22.1*	5.26*	33.32*	8.27	1.33*	0.24*	5.42*	0.44*	-
n Area	13.87*	6.85*	39.89*	11.43*	2.26*	0.64*	6.13*	0.62*	0.08*
Vest Area	25.25*	8.99*	21.94*	5.23*	1.32*	0.4*	2.86*	0.03*	0.4*
agh – Erbil	21.15*	3.56*	41.56*	6.91*	1.24*	3.1*	2.25*	0.54*	0.05*
	12.48*	6.56*	44.15*	9.19*	1.65*	1.69*	5.06*	1.03*	0.04*
n Iraq	13.08*	5.73*	46.23*	10.67*	2.3*	1.97*	4.78*	-	-
	20.53*	6.09*	37.32*	8.36*	1.94*	2.22*	3.45*	-	-
Vest Area	44.78*	5.42*	4.7*	0.94*	0.27*	0.23*	1.42*	0.19*	-
l Safra	33.81	18.2							

ements with (%) .
arsomi , 1980) / C- (Al-A'asm , 1978) / D- (Abd Al-Hameed , 1983) / E-
30) / G- (Abdul-Hassan,1977) / H- (Al- Abaidi , 1984) / I- (Al-Matheedi ,
(Majeed , 1983) / L-(Znkna , 2005) .

nges of Major elements for simples rock from the world

MgO	SiO_2	Al_2O_3	K_2O	Na_2O	Fe_2O_3	TiO_2	SO_3
1.5*	7.3*	8*	2.66*	0.96*	4.72*	4600	2400
0.7*	36.8*	2.5*	1.07*	0.33*	0.98*	1500	240
4.7	2.4*	0.42*	0.27*	0.04*	0.33*	400	1200
2.1*	25*	8.4*	2.5*	4*	6.5*	4600	1300
3.3*	50.7*	15.1*	3.5*	0.8*	4.4*	0.78*	0.31*
0.23*	293	110	590	15	113	14	46.16*
0.92*	2384	160	-	Trace	630	-	45.07*

هيم شيخ مقطع في المنغ

) -A Range and Mean of studied components in % of Fa'tha Formation, Sheik Ibrahim section

IgO	SiO_2	Al_2O_3	K_2O	Na_2O	Fe_2O_3	TiO_2	SO_3	I. R.
23	**5**	**5**	**23**	**23**	**23**	**5**	**23**	**23**
.79	9.08	2.04	2.33	0.78	1.42	0.11	0.24	19.98
.15- .55	29.8-2.52	0.47-6.96	0.16-9.58	0.15-3.43	0.26-5.31	0.03-0.4	0.08-1.18	5.99-38.33
14	**3**	**3**	**14**	**14**	**14**	**3**	**14**	**14**
.61	1.03	0.28	0.3	0.15	0.19	0.01	45.17	11.5
-2.98	0.90 1.82-	0.28-0.28	0.00-0.09	0.03-0.27	0.01-1.7	0.01-0.02	17.07-64.14	1.7-15.57
10	**3**	**3**	**10**	**10**	**10**	**3**	**10**	**10**
.14	**15.53**	**3.72**	**7.72**	**1.52**	**3.44**	**0.23**	**0.27**	**56.89**
-9.75	16.16- 26.24	3.78-6.02	1.74-25.47	0.15-4.12	0.60-6.72	0.24-0.38	0.09-0.40	20.85- 77.32
7	**6**	**6**	**7**	**7**	**7**	**6**	**7**	**7**
.17	25.41	5.631	5.85	1.14	5.33	0.34	0.28	63.38
-4.62	2.82-39.96	0.52-9.32	2.02-12.31	0.36-2.04	2.11-9.15	0.03-0.56	0.09-0.53	49.75- 81.95
1	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**1**
.17	-	-	**4.39**	**1.75**	**8.34**	-	**0.31**	**54.97**
-	-	-	-	-	-	-	-	-

الجيوكيميائية الصخرية لتكوين الفتحة في مقاطع مختارة شمال العراق

قيس محمد عبدالله البياتي و عبدالمطلب حسون المرسومي
قسم علم الارض–كلية العلوم–جامعة البصرة

المستخلص

ما مجموعه 52 نموذجا جمعت من صخور الطفال و الحجر الجيري و الجبس من تكوين الفتحة (المايوسين الاوسط)، هذه النماذج حللت اولا الى المكونات الاتية اكاسيد السليكا و الالمنيوم و و التياتانيوم و الكالسيوم و المغنسيوم و الصوديوم و البوتاسيوم و الحديد و الكبريتات و عناصر المنغنيز و الكوبلت و النيكل و الرصاص و الزنك و النحاس ثم بعد ذلك حللت معدنيا من خلال تقنية الاشعة السينية.كما حسبت كمية الفضالة غير الذائبة. التحليل المعدني اثبت و جود المعادن الاتية: الجبس و الكالسايت و الدولومايت و الفلدسبار و الكوارتز. المعادن الطينية تتألف من معادن الالابت والباليغورسكايت و الكاؤلينايت و الكلورايت و المونتموريلونايت و الطبقات المختلطة من الكلورايت و المونتموريلونايت في نسب مختلفة. الالفة الجيوكيميائية و التركيب المعدني هما المسيطران على توزيع العناصر قليلة التركيز في الوحدات الصخرية لتكوين الفتحة. العمليات التحويرية التي اثرت على صخور تكوين الفتحة تتمثل بعمليات تميؤ الانهادرايت و اعادة التبلور و الدلمتة، سببت العمليات التحويرية تغير في تراكيز العناصر الرئيسة و النادرة نتيجة

حركة هذه العناصر خلال العمليات التحويرية، التوزيع العمودي للمعادن الطينية يشير إلى وجود تذبذب في ملوحة مياه حوض الترسيب و معدل تجهيز الفتاتيات خلال ترسيب تكوين الفتحة