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BIOSTRATIGRAPHY AND PALEOTEMPERATURE OF JURASSIC SEQUENCES IN MIDDLE PART OF PERSIAN GULF, SOUTH OF IRAN

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Abstract

The Persian Gulf is a mediterranean sea in Western Asia. An extension of the Indian Ocean (Gulf of Oman) through the Strait of Hormuz, it lies between Iran to the northeast and the Arabian Peninsula to the southwest. The studied Sequence is related to Neyriz, Surmeh and Hith Formations. Neyriz Formation has a thickness of 12 meters consists of Limestone, the samples of this formation are without microfossils, based on Lithostratigraphy situation belong to Early Jurassic. Surmeh Formation is the oldest Formation of Khami Group. In this study, The Surmeh Formation in the studied well is located on Neyriz Formation and under Hith Formation with paraconformity. This formation has a thickness of 687 meters and consists of limestone, dolomite, shale and anhydrite. In this study by an analysis of 1400 samples and based on paleontological studies 5 biozonation include of *Lithiotis* Range zone, *Pfenderina* Range zone, *Trocholina* zone, *Kurnubia jurassica* Interval zone, *Clypeina jurassica*, have been determined. Early to Late Jurassic age of Surmeh Formation is based on identificated genera, species and biozones. Hith Formation has a thickness of 90 meters consists of Anhydrite , so we don't find any microfossils in this formation and based on Lithostratigraphy situation belong to Late Jurassic. Palaeotemperature calculation, based on the heaviest oxygen isotope value in the upper Surmeh Formation shows that ambient water temperature was around 23.8 ℃ during the deposition of this formation.

***Key words*: Biostratigraphy, Jurassic, Persian Gulf, Khami Group, Paleotemperature, Iran**

Introduction

The Neyriz Formation is mainly consist of thin- bedded carbonates and shale grading upward into quartzose sandstone (some conglomerating beds) derived from the northeast with intercalations of thin argillaceous limestone near the top: unconformbaly onlaps Triassic strata. Surmeh formation (Dogger- Malm) is one of the carbonates units of Khami Group that is one of the important hydrocarbon reservoirs Zagros Basin.

The Surmeh Formation is the lowermost lithostratigraphic unit of the Lower Jurassic to Lower Cretaceous Khami Group [22] James and Wynd named and measured the Surmeh type section in the Fars Province about 120 km south of Shiraz. In the type locality (Surmeh section) and in the Khaneh-Kat section, the formation consists mainly of dolomite and limestone and is bounded, with unconformable contacts, by the lowermost Jurassic Neyriz Formation and the lowermost Cretaceous Fahliyan Formation.

The Surmeh Formation is up to 1,000 m thick and forms an important petroleum reservoir in a number of giant oil fields in the Persian Gulf area. Previous studies on the Surmeh Formation have focused on general lithostratigraphy [14, 20, 22,]. The formation has been referred to as a shallow marine carbonate succession [14, 20, 22].

In order to biostratigraphic study of Jurassic sediments, bentic and pelagic foraminifera, calpionella and bivalve are determined. The best extension of Surmeh Formation is in Fars provinc. This Formation is the oldest Formation of Khami group at the age of Lower to Upper Jurassic (Toarcian-Tithonian) and it is located in the Zagros folded-faulted belt and high Zagros belt [14, 20, 22,]

The Hith Formation is the last major cycle of the Upper Jurasic sequences in the Persian Gulf region. this formation is charecterized by repetive shallowing-upward progradation carbonate to evaporite depositional sabkha cycles. the thickness of this formation encountered in wells in Lavan and Kish Islands in the Iranian waters of the Persian Gulf ranges from 73 to 92 meters. However, in many localities in Iran the thickness of this formation ranges from 30 to 150 meters.

The Geology of Study Area

The Persian Gulf with an area of approximately 90,000 square miles is underlain in its entirety by continental shelf. The average water depth is generally less than 40 fathoms (240 feet). The Gulf is virtually an enclosed sea with the only opening being in the east through the Strait of Hormuz. Eight states border the Persian Gulf: Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

Potentially, at least 16 continental shelf boundaries will be required in this region (for the purpose of this study internal United Arab Emirates boundaries are not considered). Seven boundaries have been negotiated of which the following six have entered into force: Bahrain-Iran Bahrain-Saudi Arabia Iran-Oman Iran-Qatar Iran-Saudi Arabia Qatar-United Arab Emirates (Abu Dhabi). [24]

In this study, Biostratigraphy of Jurassic Sequences in middle part of Persian Gulf have been studied (figure 1).

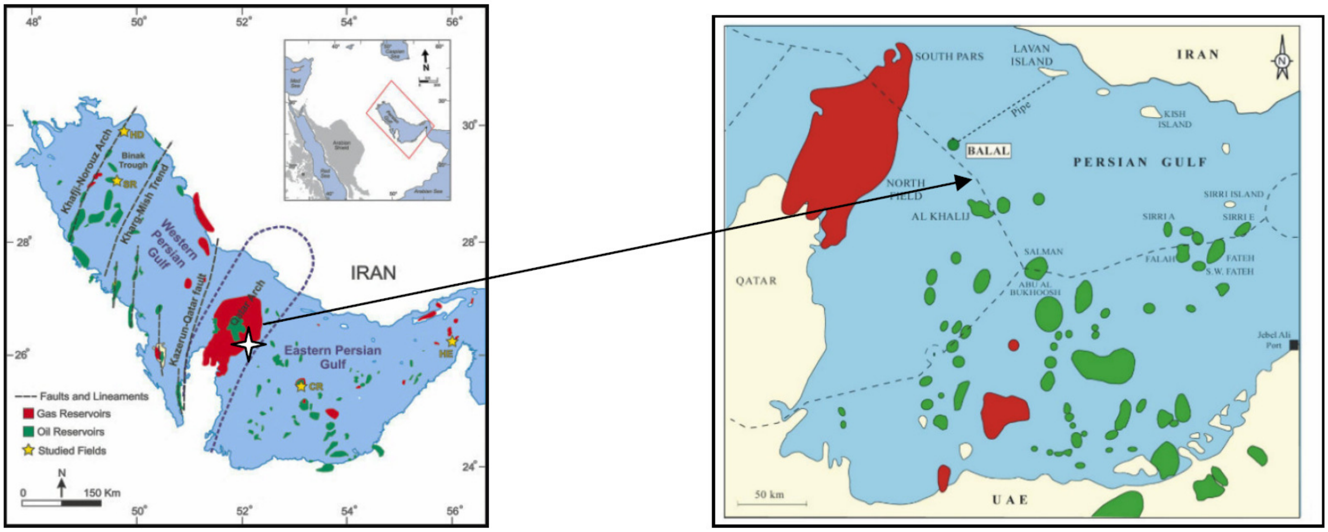

Fig. 1 : Location map of studied areaObjective and Methodology

The aim of these samples analysis was attempt to: Determination of Microfossils, introduction of Biozones and Age Detection.

Lithostratigraphy

Neyriz Formation has a thickness of 12 meters consists of Limestone. Surmeh Formation in the studied section is located on Neyriz Formation and under Hith Formation with paraconformity. This formation has a thickness of 687 meters and consists of limestone, dolomite, shale and anhydrite.

Hith Formation has a thickness of 90 meters consists of Evaporite Mineral Anhydrite.

Biostratigraphy

Larger benthic foraminifera are widely distributed in the Jurassic carbonate platform. They developed complicated internal structures that are identifiable when sliced into thin sections. These organisms can provide detailed information for the biostratigraphic analysis of the shelf limestone because of their rapid diversification, abrupt extinction and abundance.

In the studied sediments, there are 4 groups of microfossils including foraminifera (benthic with high frequency) and calcareous algae, Bivalve and Crinoid which allow the age determination. Study of foraminifera was performed by using thin sections of limestone, while algae were studied by using thin sections of limestone. Finally,

5 Biozone of foraminifera and Algae and Bivalve were documented in the studied area and are discussed in ascending stratigraphic order as follows :

Biozone1: *Lithiotis* Range zone

Early Jurassic corresponding to zone 3 (Wynd, 1965). Imortant taxa include: *Lithiotis*

Biozone2: *Pfenderina* Range zone

Middle Jurassic corresponding to zone 5 (Wynd, 1965). Imortant taxa include: *pfenderina trochoidea, Kurnubia jurassica, Trocholina palastinensis, Trocholina* sp., *Mangashtia viennoti, Nautiloculina oolithica, Epistomina* sp., *Lituolidae,., Textularidae sp., Ostracods*

Biozone3: *Trocholina palastinensis-Trocholina* Assemblage zone

Middle to Late Jurassic corresponding to zone 6 (Wynd, 1965). Imortant taxa include: *Trocholina palastinensis, Trocholina elongata, Thaumatoporella parvovesiculifera, Nautiloculina oolithica, Nautiloculina circularis, Tautloporella* sp, *Textularidae*

Biozone 4: Kurnubia jurassica Interval zone

Late Jurassic corresponding to zone 7 (Wynd, 1965). Imortant taxa include: *Kurnubia jurassica, Kurnubia sp, Kurnubia morrisi, Mangashti viennoti, Nautiloculina oolithica, Glomospirella sp., Amijiella amiji, Paleogaudryina* sp., *Verneuioina sp. Salpingoporella annulata, small Textulariids, Miliolids, Lenticulina* sp, *Cylindroporella* sp

Biozone 5: *Clypeina jurassica* zone

Late Jurassic corresponding to zone 8 (Wynd, 1965). Imortant taxa include: *Kurnubia jurassica, Nautiloculina oolithica, Clypeina jurassica, Salpingoporella annulata, Siphovalvulina variabilis, Siphovalvulina gibraltaerensis., Verneoillina minuta, Glomospirella* sp., *Miliolida, Textularids,*

Pseducyclammina lituus, Lenticulina sp, *Mangashti viennotti, Everticyclammina virgulina, Cyclamminidae., Saccocoma* sp.

Isotopic analysis ($\delta\ ^{18}O$ and $\delta\ ^{13}C$)

6.1 Carbon isotopic values for temperature determination

Oxygen in carbonates: palaeotemperature equations the oxygen isotopic composition of a carbonate mineral which is precipitated in equilibrium with its environment is determined by the oxygen isotopic composition of the fluid from which the mineral precipitated and the temperature of precipitation. The fractionation effects are relatively large, with precipitated carbonates having isotopic compositions typically around 25-30% greater than the water from which they formed. Different carbonate minerals have slight differences in fractionation: palaeotemperature equations are accordingly different for each mineral. The relationship for calcite is commonly expressed in one of two forms which give very similar results for water compositions and temperatures typical of most earth surface conditions: An empirical formula derived from measurements of the isotopic composition of the shells of calcareous organisms grown under different conditions (Epstein et al. 1953; Craig, 1965).

The equation as expressed in relation to commonly used international standards by Anderson &Arthur (1983) gives T(°C) = 16.0-4.14(5c-<U + 0.13(Sc-(U2, where Sc = the oxygen isotopic composition of the calcite with respect to the PDB international standard, and #w = the oxygen isotopic composition of the water from which the calcite was precipitated with respect to the SMOW international standard.

The equilibrium carbon isotopic fractionation effects between precipitating carbonate and surrounding bicarbonate are relatively small and temperature effects are relatively minor. For example, the relationships determined by Emrich, Ehhalt & Vogel (1970) imply an enrichment in the solid of 1.85%O at 25 °C and that #13Ccalclte increases by approximately 1 %0 for every 27 °C increase in temperature. Precipitated aragonite also has higher S13C than ambient dissolved inorganic carbon but the fractionation seems to decrease with increasing temperature (Grossman & Ku, 1986). The relatively minor temperature dependency of the fractionation effects, and uncertainties over the magnitude of variation, negate the use of but stratigraphic changes in carbonate carbon values are extremely useful as indicators of changes in the composition of the marine bicarbonate reservoir.

Objective and Methodology

The aim of stable isotope analysis was attempt to:

- To distinguish the different diagenetic environments of the main phases of calcite/dolomite precipitation from the initial step of sedimentation to the successive phases of matrix recrystallization and/or late cementation
- To interperate this information in terms of "parent water" origin, carbon origin and precipitation temperature.

The final objective was to interpret the relative timing of this phases of precipitation, with a continuous control from petrographic observations, and to assess the possible influence on reservoir properties.

These analyses have been performed following two steps:

- Isotopic analyses on whole rock samples
- Isotopic analyses of specific elements as bioclasts, calcite or dolomite crystals

The carbon and oxygen isotopic composition of carbonates is reported in conventional '8' notation as 'parts per thousand' (% J difference between an isotopic ratio (^{18}O/^{16}0,^{13}C/^{12}C) in a sample compared to the same ratio in an international standard. Carbon and oxygen data are generally both referred to the PDB carbonate standard but water compositions and some carbonate oxygen values are reported with respect to the SMOW ocean water standard; the scales are related by a simple equation (Friedman &O'Neil, 1977) such that *^{18}Ocalcite (vs SMOW) =1.03086 tf18Ocalclte (vs PDB) + 30.86

Analytical results

- Isotopic analyses on whole rock samples: δ^{18}O values range from -0.9 to -5.3% PDB and δ ^{13}C values range from +0.2 to +3.1% PDB. Analytical data are given in Table 1 Isotopic analyses on selected microsamples: the drawback of Isotopic analyses performed on whole rock sample is that the obtained compositions corresponded to an average value of the isotopic composition of various elements compositing the rock sample. Knowing that, in such facies, the average value can hide a wide range of values, the analysis of specific and selected elements can help for interpretation. Six samples have been selected and eighteen microsamples have been sampled and analyzed.
- Results are given in table 1,2
- Carbon- oxygen isotopic composition of calcite Bivalve shell, apparently fresh and not recrystallized, corresponded to +0.7% PDB for δ ^{13}C value and -4.2% PDB for δ ^{18O} values. These data could be considered as data reflecting a "marine reference" likely slightly shifted by calcite re-equilibration phenomena

Interpretation

- Thermal fractions curves from δ^{18}O data: Thermal fractions curves can be used as an help for interpretation, in terms of precipitation temperature or/and parent water composition. This method assumes that, during precipitation temperature, the carbonate solid phase is in equilibrium with the liquid phase, called the parent water. Moreover, it is known that depletion in ^{18}O could either be due to late thermal re-equilibration during burial, or to early diagenesis involving continental waters. So, assuming hypotheses concerning precipitation temperature, fractionation equations can be applied to calculate the water isotope composition in equilibrium with the analyzed carbonate. Alternatively, assuming the original parent water composition as, in case of marine origin with ^{18}O values comprised between 0 and -2% SMOW or in case of meteoric origin with very depleted ^{18}O values, the precipitation temperature can be determined.
- Thermal fractionation curve calculated for selected sample: so sedimentation of sea water paleotemperature ranging from 20 ºC to 30 ºC.

Conclusion

These Jurassic Sequence in this studied section is related to 3 Foramation include Neyriz, Surmeh and Hith Formations.

Neyriz Formation has a thickness of 12 meters consists of Limestone, the samples of this formation are without microfossils, based on Lithostratigraphy situation belong to Early Jurassic.

Surmeh Formation has a thickness of 687 meters and consists of limestone, dolomite, shale and anhydritie. In this study by an analysis of 1400 samples and based on paleontological studies 5 biozonation include of *Lithiotis* Range zone, *Pfenderina* Range zone, *Trocholina* zone, *Kurnubia jurassica* Interval zone, *Clypeina jurassica* have been determined. Early to Late Jurassic age of Surmeh Formation is based on identificated genera, species and biozones.

Hith Formation has a thickness of 90 meters consists of Anhydrite. So we don't find any microfossils in this formation and based on Lithostratigraphy situation belong to

Early to Late Jurassic. We selected 6 sample of whole core & 8 microsamples for Stable carbon and oxygen isotope analysis Palaeotemperature calculation, based on the heaviest oxygen isotope value in the upper Surmeh Formation in middle part of Persian Gulf shows that ambient water temperature was around 23.8 ºC during the deposition of this formation.

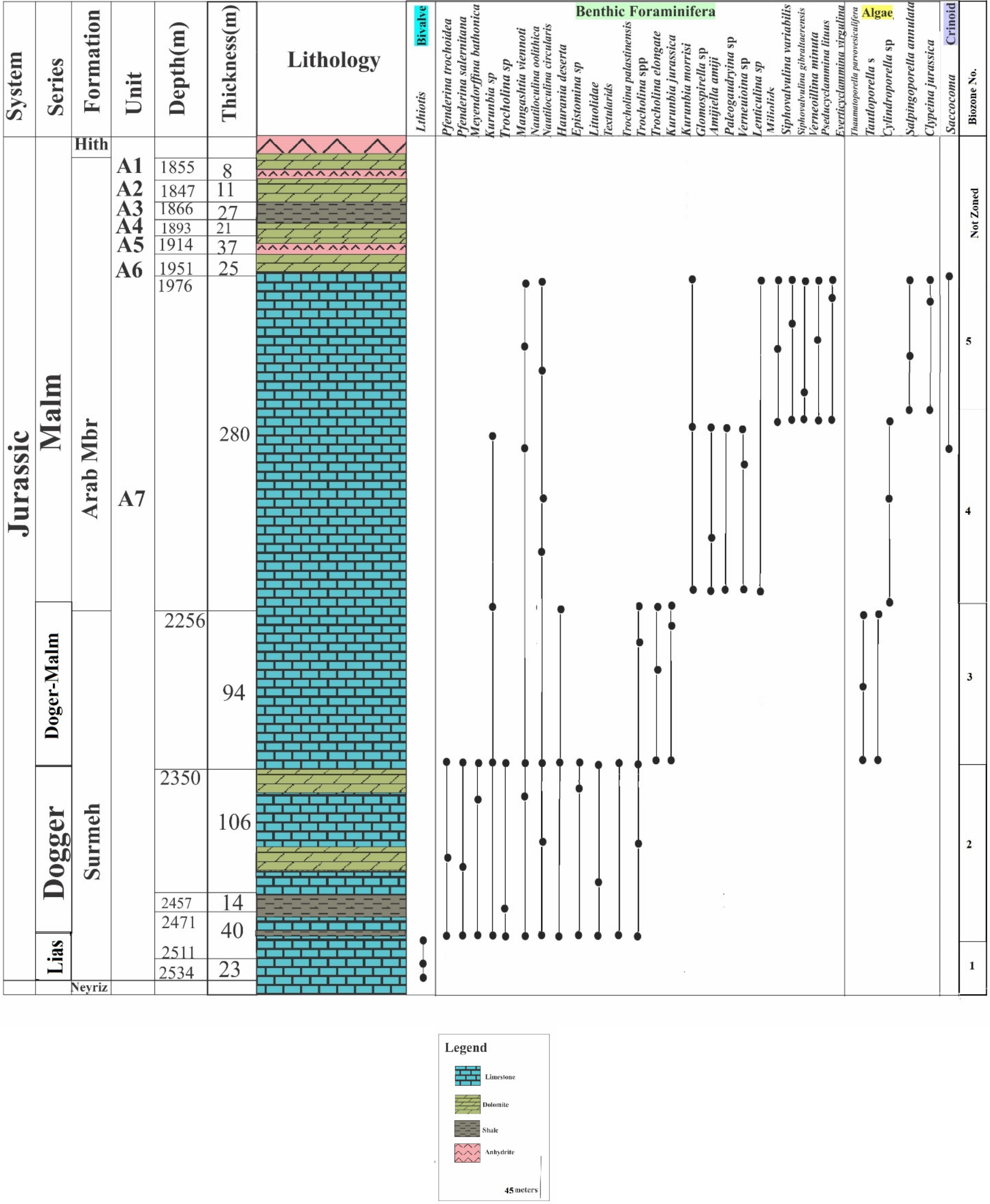

Fig. 2 : Biostratigraphy column of Jurassic Sequences in Middle part of Persian Gulf

PLATE 1

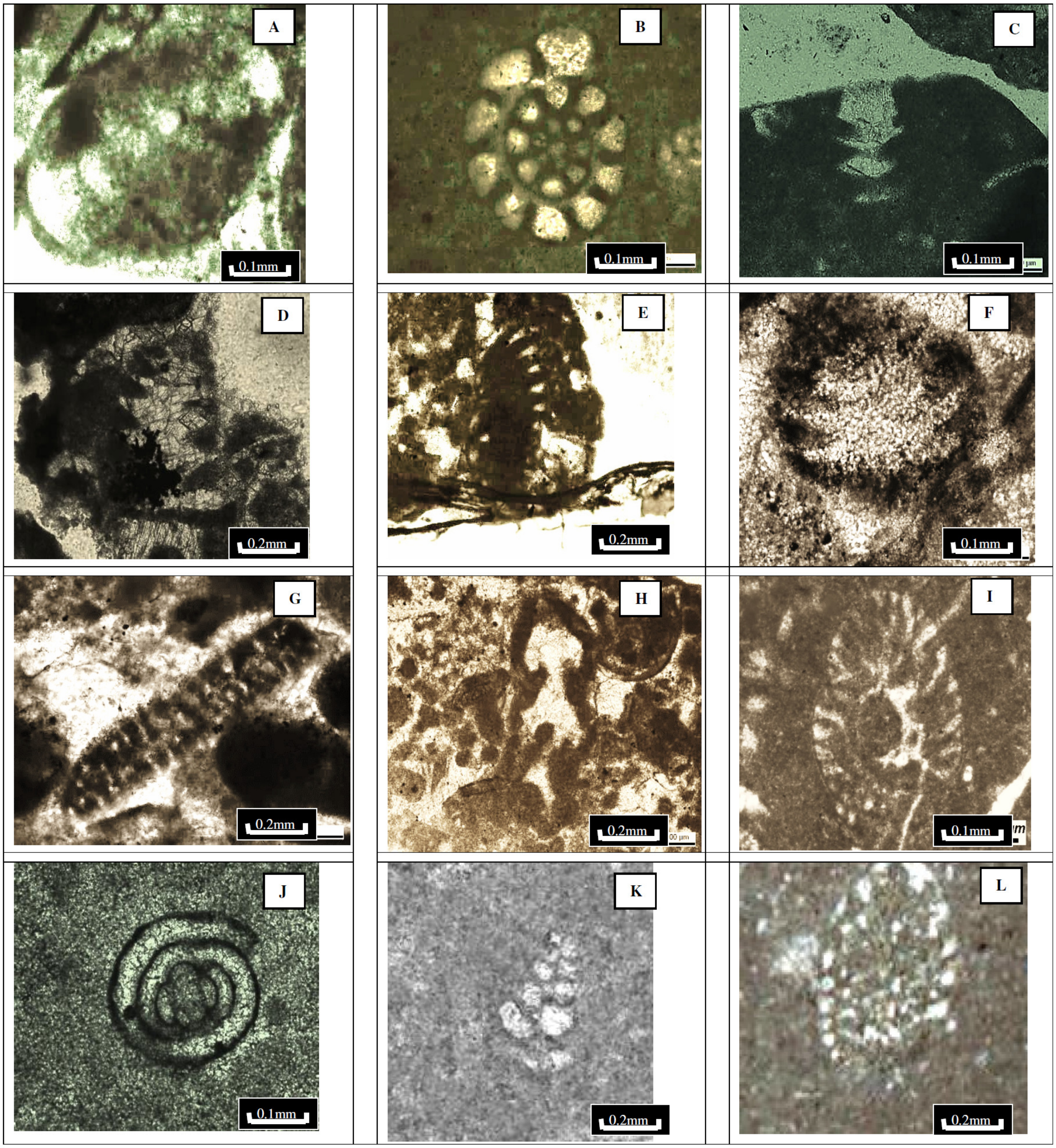

Plate 1) A,B) *Nautiloculina oolithica,* C,D) *Trocholina elongata*, E) *Pfenderina* sp, F) *Trocholina palastinensis,* G) *Mangashtia viennoti,* H) *lithoulidae,* I) *Kurnubia Palastinensis*. J) *Glomospirella* sp K) *Verneoillina minuta,* L) *Kurnubia* sp.

PLATE 2

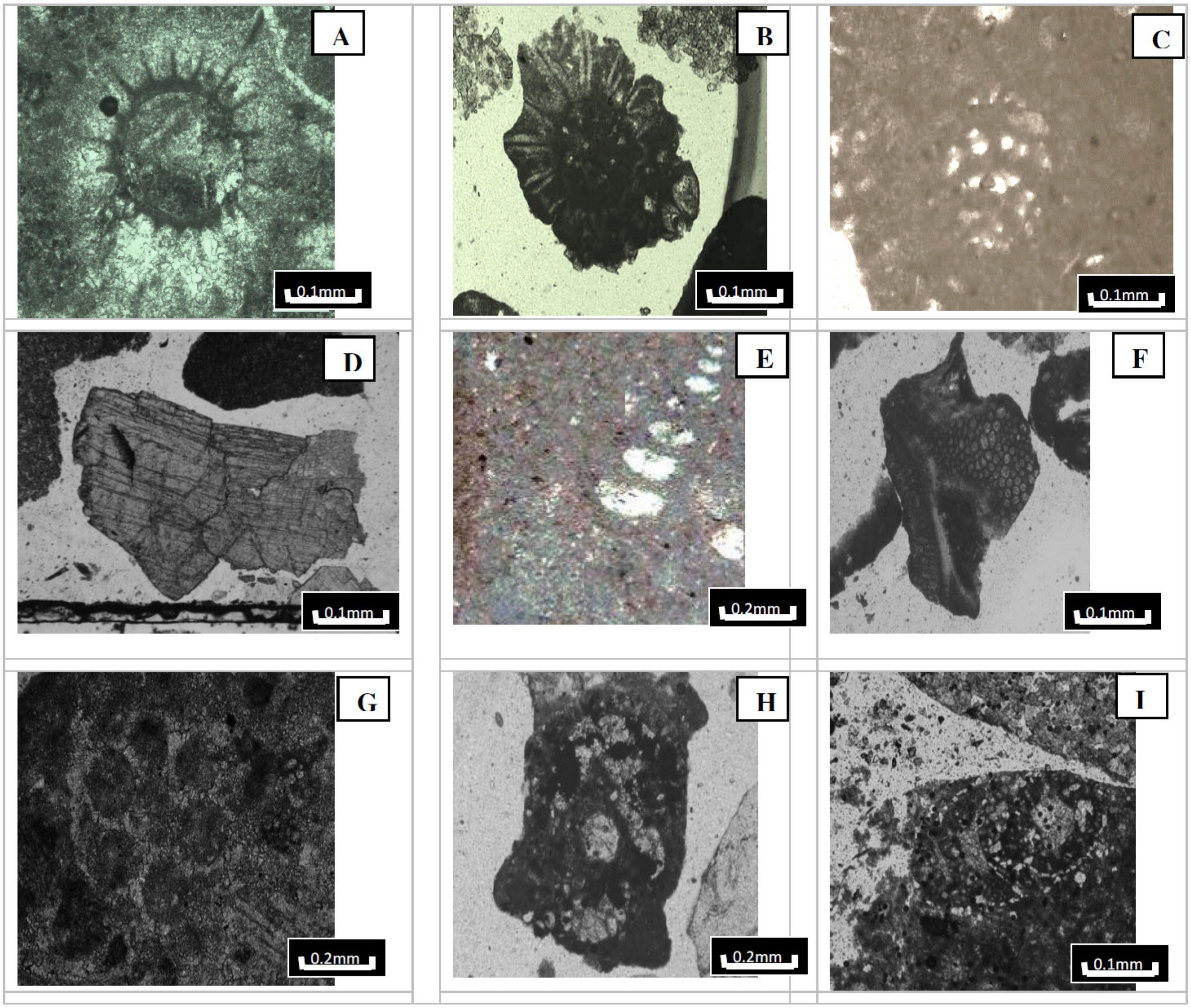

Plate 2) A,B) *Clypeina Jurassica,* C) *Kurnubia jurassica*, D) *Lithiotis*, E) *Palepgaudryna,* F) *Thaumatoporella parvovesiculifera,* G) *Cylindroporella* sp, H) *Everticyclammina* sp. I) *Pseudocyclammina lituus*

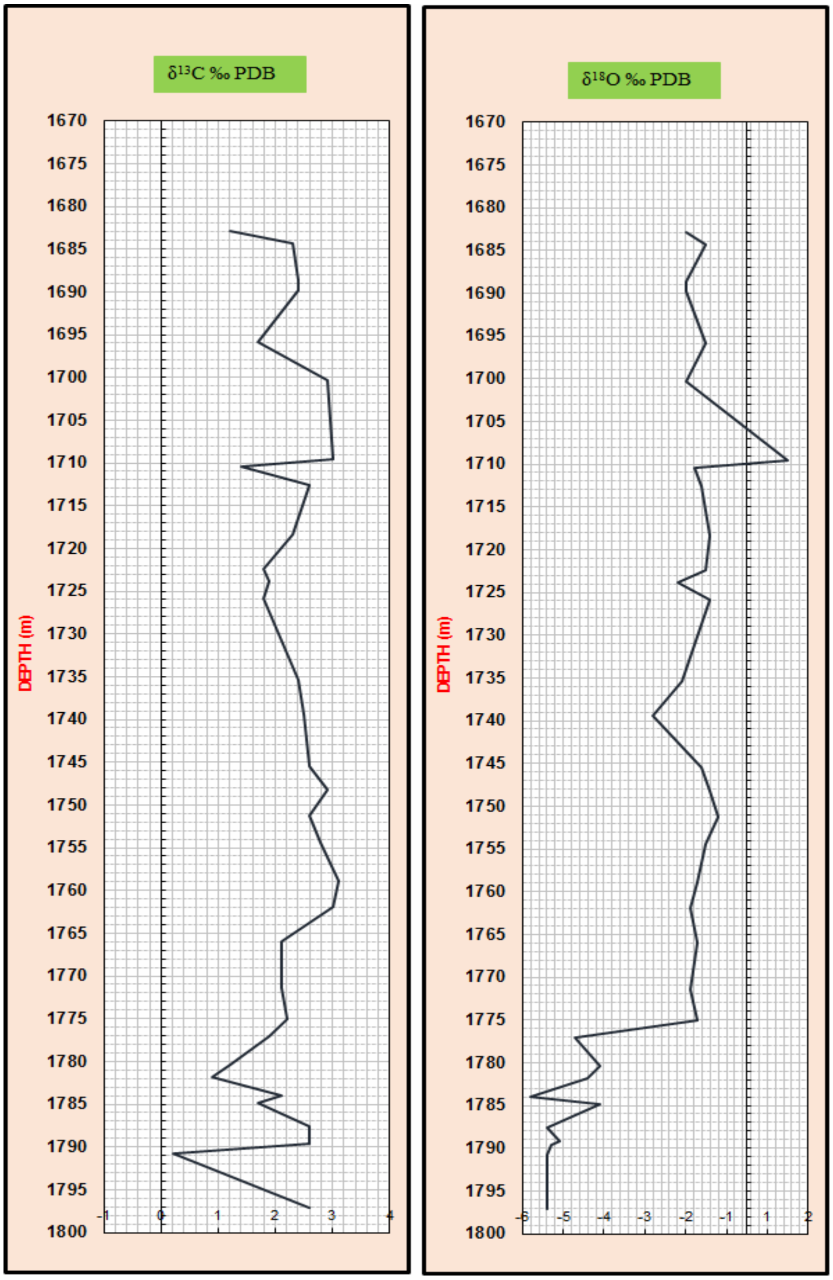

Fig. 3 : Carbon and Oxygen isotopic profile versus depth

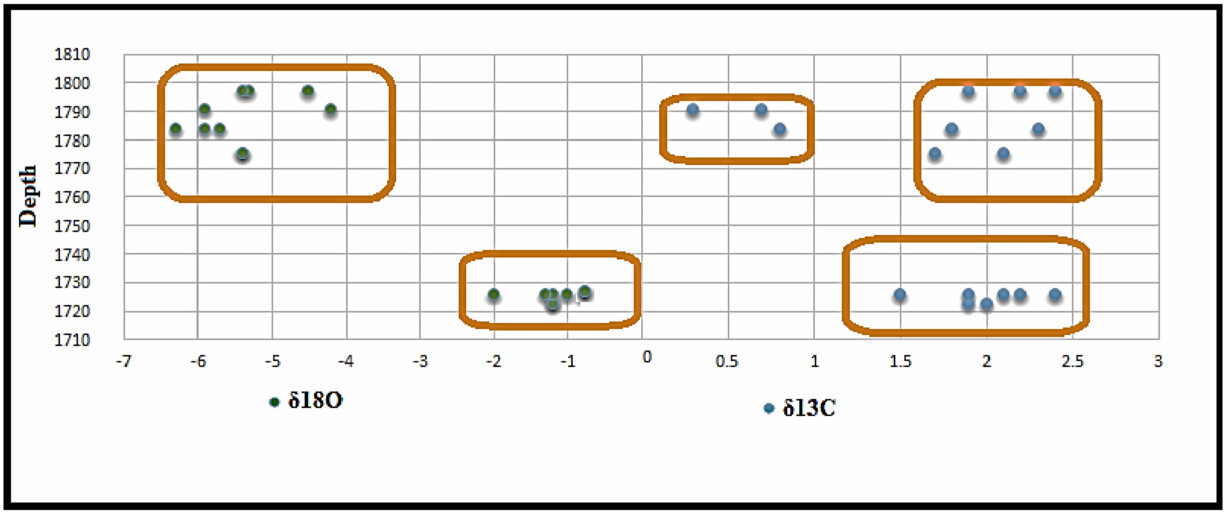

Fig. 4 : Carbon and Oxygen isotopic profile versus depth in microsamples

Table 1 : Carbon and Oxygen isotopic value in whole core

Depth(meter)	Carbonate Type	$\delta^{13}C$ ‰ PDB	$\delta^{18}O$ ‰ PDB
1683	Dolomite	1.2	-1.5
1684		2.3	-1
1689		2.4	-1.5
1690		2.4	-1.5
1696		1.7	-1
1700		2.9	-1.5
1710		3	1
1710		1.4	-1.3
1713		2.6	-1.1
1718		2.3	-0.9
1722		1.8	-1
1724		1.9	-1.7
1726		1.8	-0.9
1735		2.4	-1.6
1739		2.5	-2.3
1746		2.6	-1.1
1748		2.9	-0.9
1751		2.6	-0.7
1754		2.8	-1
1759		3.1	-1.2
1762		3	-1.4
1766		2.1	-1.2
1771		2.1	-1.4
1775	Calcite	2.2	-1.2
1777		1.9	-4.2
1780		1.2	-3.6
1782		0.9	-3.9
1784		2.1	-5.3
1785		1.7	-3.6
1788	Dolomite	2.6	-4.9
1789		2.6	-4.6
1790	Calcite	2.6	-4.8
1791		0.2	-4.9
1797		2.6	-4.9

Table 2 : Carbon and Oxygen isotopic value in microsamples

Depth(meter)	Sample Type	$\delta^{13}C$ ‰ PDB	$\delta^{18}O$ ‰ PDB
1722	Gastropod	2	-1.2
1722	Dolomite	1.9	-1.2
1726		1.9	-2
1726		1.5	-1.2
1726	Peloids	2.4	-0.8
1726	Dolomite	2.2	-1
1726		2.1	-1.3
1775	Calcite	2.1	-5.4
1775		1.7	-5.4
1784		0.8	-6.3
1784		1.8	-5.9
1784		2.3	-5.7
1791	Bivalves	0.7	-4.2
1791	Calcite	0.3	-5.9
1797	Madreporaria	1.9	-4.5
1797	Calcite	2.2	-5.3
1797		2.4	-5.4

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