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ON THE OCCURRENCE OF PRIMARY DOLOMITES IN QATRANI FORMATION (OLIGOCENE) IN FAYOUM PROVINCE, WESTERN DESERT, EGYPT

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ABSTRACT

This work represents a study of petrographic properties, differential thermal analysis and *x*-ray diffraction study of carbonate rocks of the Qatrani formation of Oligocene age in Fayoum Province, Egypt. These carbonate rocks can be grouped into three major textural and compositional types. Microcrystalline dolostones or dolomicrite, gypsiferous dolomicrite and dolomitic sandstones.

INTRODUCTION

Thin dolostones and dolomitic rocks are interbedded with shales, sandstones and gypsum in the Qatrani Formation, 618 feet in thick (Oligocene), in Fayoum Province, Egypt. The thickness of these bands ranges from one foot to 8 feet; that of the interbedded terrigenous sediments from one foot to 48 feet.

In addition, quartz grains are disseminated throughout many of the dolostones, all variations are present from nearly pure dolostones with a few scattered quartz grains to dolomitic sandstone.

The present paper describes the petrographic properties of the carbonate rocks from the Qatrani Formation of Oligocene age in Fayoum Province, in addition to differential thermal analysis, x-ray diffraction and chemical analysis. The purpose of this work to show that the dolostones are of primary or secondary in origin. It is hoped that this study will shed more light on the nature of this carbonate rocks. *Fig. 1* shows the location of Gebel Qatrani.

STRATIGRAPHY AND GENERAL LITHOLOGY

The Quatrani Formation was established by BEADNELL [1905] to represent the fluviomarine sediments below the basalt and above the Kasr El Sagha Formation (Upper Eocene) exposed at the Gebel Qatrani, Fayoum Province, Egypt. The formation is predominantly a terrigenous unit with eight dolomite bands. The detailed stratigraphy and lithology of the formation has been discussed by BEADNELL [1905], BLANCKENHORN [1921], CUVILLIER [1926] and recently by ISMAIL and ABDEL-KIREEM [1971*a* &*b*].

The Qatrani Formation (Oligocene) is represented by a section 618 feet thick, exposed at Gebel Qatrani, composed of 40.05% sandy shales, 18.4% sandstones, 15.0% shales, 7.36% calcareous sandstones, 2.95% gypsiferous shales, 3.7% dolostones, 1.29% dolomitic sandstones, 0.27% sandy marls, 0.2% gypsum, and 10.7 % basal as a sheet capping the whole formation [ISMAIL and ABDEL KIREEM 1971*a*]. The succession is only fossiliferous with a rich vertebrate fauna, in addition to silicified wood fragments.

METHODS OF STUDY

Eighty five samples from the Qatrani Formation were collected, unfortunatly only eight samples are of dolomites. These dolostones and dolomitic rock samples were thin sectioned, about 40 thin section were prepared for a detailed petrographic analysis. The rock samples were chemically analysed for the determination of insoluble residue, R_2O_3 ($=Fe_2O_3+Al_2O_3$), CaO, MgO, slouble Cl^-, in addition to the Ca/Mg ratios. Minerals of sediments of Qatrani Formation were studied by differential thermal analysis and x-ray diffraction.

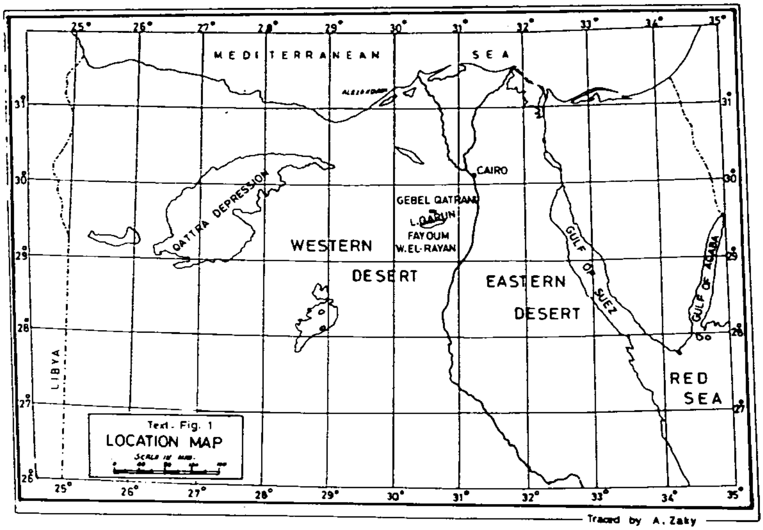


Fig. 1.

PETROGRAPHY AND CARBONATE NOMENCLATURES

The carbonate rocks at Qatrani Formation can be grouped for descriptive purposes to three major textural and compositional types which are:

1) Microcrystalline dolostone or dolomicrite.
2) Gypsiferous dolostone (dolomicrite).
3) Dolomitic sandstone.

It is emphasized that these classes are rather arbitrary and set up for convenience: all transitions between first and third classes are present.

Type 1: Microcrystalline dolostone or dolomicrite (Plate I—II, 1—5): In this category are those dolostone rocks containing not less than 16.7% MgO, comprising samples No. 3Q, 46Q, 61Q, 72Q and 76Q.

These microcrystalline dolostones alternates with zones of red shales, sandstones and gypsum. Hematitic material is in almost all rocks of this class and mostly in amounts about 7% except for the first dolostone band 3Q. They all show nearly similar petrographic characters, generally with much coarse grained quartz. The quartz grains are angular to subrounded and are embedded in a microcrystalline dolomitic matrix of uniform textures. Abundant oval to rounded cavities filled with dolomites are present in some thin sections represented by samples 46Q, 61Q and 72Q. Clay exists in some beds but mostly in minor amounts.

Type 2: Gypsiferous calcitic magnesit (Plate II, 6—7): In this class are rocks containing "layered" and void filling gypsum which is intimately associated with the fine grained magnesite. This calcitic magnesite alternate with zones of brown to red shales, yellow to red sandstone and gypsiferous shales. This type is represented by samples No. 38Q and 63Q. Hematitic materials are generally present, the thin sections are deeply stained by this hematitic materials. Abundant fine to coarse quartz grains scattered throughout the matrix.

This microcrystalline calcitic magnesite rock is interlaminated and intermixed irregularly with the gypsum.

On the origin of "layered" gypsum, MURRAY [1954] suggested that it may be due to precipitation and sedimentation in a standing body of water subjected to continuous evaporation.

Type 3: Dolomitic sandstone (Plate II, 8): Dolomitic sandstone constitutes a relatively thick bed (8 feet thick) of the Qatrani Formation relative to the other dolomitic beds. This type is represented by sample No. 73Q. The quartz sand which constitute about 51 % are angular to subrounded, ill-sorted and size range from 0.02 mm to 20.0 mm. This detrital material was derived from an older sediment, most probably the Upper Eocene Kasr El Sagha Formation.

The ferric oxide mineral hematite and the ferric hydroxide mineral (?) limonite are respectively responsible for the red and brown colors of the Qatrani Formation considered in this study. Although hematite is the dominant ferric mineral, considerable limonite is also present and the coexistence of the two minerals, often found together within single zones in dolomite rhombohedra suggests that much of the hematite may have resulted from the partial dehydration of original limonitic zones. Most of the limonite and hematite occurs either finely dispersed through dolomite (*Plate I—II, 2, 6 & 7;* samples 46Q, 38Q and 63Q respectively) or as concentrated zones in dolomite rhombohedra (*Plate II, 5,* sample 76Q).

EXPERIMENTAL WORK

Some of sediments, mainly carbonates of the Qatrani Formation were subjected to differential thermal analysis and *x*-ray diffraction.

Techniques of work:

Differential thermal analysis procedure: Differential thermal analysis were carried out for the 8 carbonate samples from Qatrani Formation. These samples were chosen to reflect the different types of carbonate in the whole formation. The samples were ground to −200 mesh.

Differential thermal analysis technique: Differential thermal analysis experiments were carried out by using F. PAULIK, J. PAULIK and L. ERDEY derivatograph. This apparatus records simultaneously four thermal curves: (T) the change of temperature of the sample, (DTA) differential thermal analysis, (TG) thermogravimetric, (quantitatively in mg) and (DTG) derivative thermogravimetric, on a single sample under controlled conditions. DTA and temperature measuring thermocouples are Pt/Pt-Rh wires. Ceramic crucible and a ceramic sample holder were used. Alumina, calcinated at 1000 °C was used as a reference material. The parameters during tests were as follows: weight of sample 1 g, T-1200 °C, DTA-1/10, 1/20, DTG-1/10, TG-500 mg and heating rate of 10 °C per minute. All determinations were carried out in air atmosphere.

X-ray diffraction analysis procedure: A Siemens Crystalloflex diffractometer was used with nickel filtered copper radiation. Exposure was one hour and scanning speed was 1° 2Θ per minute, at 1 cm per minute chart speed. Intensities were collected to maximum $2\Theta=65°$. The sensitivity of the experiment was 1×10 impl./min., and the statistical error was 1.5%.

RESULTS AND DISCUSSIONS

The results obtained for DTA of carbonate sediments of Qatrani Formation (Oligocene), Fayoum Province are given in Table 1 and graphically shown in *Fig. 2*.

On the basis of DTA results the carbonate minerals of Qatrani Formation could be grouped into:

1) Dolomite—Calcite—Magnesite associations represented by samples 3Q, 46Q, 61Q, and 76Q.
2) Magnesite—Calcite—Dolomite associations represented by sample 72Q.
3) Gypsum—Magnesite—Calcite associations represented by samples 38Q and 63Q.

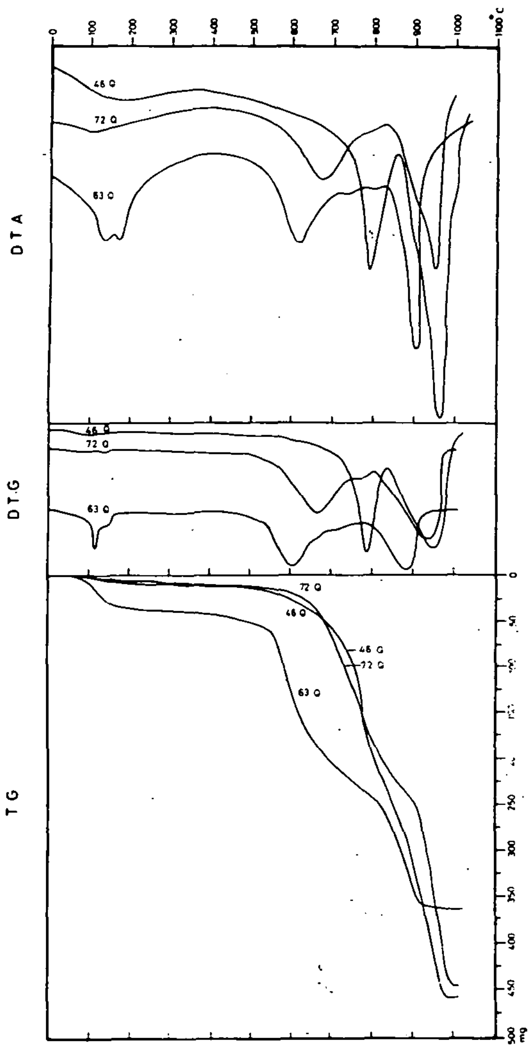


Fig. 2. DTA, DTG and TG curves for three representative carbonate samples from Qatrani Formation, Fayoum

Chemical Composition of Carbonate Sediments of Qatrani Formation.
(Data obtained from DTA and Chemical Analyses are tabulated.)

Sample No.	Analysis	CaO in Calcite	CaO in Dolomite	Total CaO %	MgO in Magnesite	MgO in Dolomite	Total MgO %	Calcite %	Magnesite %	Dolomite %	R_2O_3 %	Insoluble Residue %	H_2O %	Total %	Gypsum %	Ca/Mg ratio	Cl^- ppm
76Q	DTA	4.98	13.50	18.48	12.48	9.84	22.32	8.87	26.22	44.41	7.28	12.19	1.10	100.07	—	0.98	
	Chemical			18.30			22.41				7.13	12.29	1.10				1355
73Q	DTA	0.33	13.29	13.62	1.92	9.6	11.52	0.58	3.80	43.66	2.04	50.04	0.50	100.62	—	1.40	
	Chemical			14.02			11.11				2.00	49.35	0.50				250
72Q	DTA	20.62	4.52	25.14	18.7	3.19	21.89	36.70	38.95	14.67	7.06	2.28	0.50	100.16	—	1.36	
	Chemical			24.63			21.97				7.11	2.25	0.50				220
63Q	DTA	14.56	3.47	18.3	14.16	2.54	16.70	25.91	29.45	11.55	11.34	18.24	3.5	99.99	17.2	1.28	
	Chemical			17.81			16.81				11.31	18.32	3.5				1904
61Q	DTA	8.22	22.07	30.29	2.83	15.88	19.05	13.68	6.08	72.59	6.54	1.04	0.8	100.73	—	1.88	
	Chemical			30.01			20.01				6.11	1.00	0.8				308
46Q	DTA	5.29	24.70	29.99	1.1	17.76	18.86	9.42	2.28	81.21	5.5	1.16	0.5	100.07	—	1.88	
	Chemical			30.03			18.51				5.1	1.07	0.5				332
38Q	DTA	24.14	—	24.14	9.93	—	9.93	42.96	18.60	—	10.36	24.04	4.0	99.96	11.4	2.88	
	Chemical			24.00			10.03				9.76	23.81	4.0				5992
3Q	DTA	3.79	26.00	29.79	2.28	18.72	21.00	6.74	4.75	85.55	0.65	3.08	0.7	101.47	—	1.68	
	Chemical			29.73			21.00				0.65	3.00	0.7				325

Dolomite—Calcite—Magnesite association

This association is represented by sample No. 46Q, *Fig. 2* .The dolomite forms the major mineral constituent (44.1% up to 84.15%) with considerable amounts of calcite (6.77%—13.68%) and magnesite (2.28%—26.22%).

The T curve is generally smooth and has a gentle slope with slight concavities at 800 °C and 950 °C reflecting the dissociation of dolomite and $CaCO_3$ respectively. The DTA curve shows two sharp endothermic peaks. The first at 800 °C corresponding to the decomposition of dolomite into MgO and $CaCO_3$. The second peak at 950 °C is large and sharp representing the decomposition of $CaCO_3$. The DTG curve shows similar peaks as DTA curve but at lower temperature than DTA peaks (790 and 940 °C respectively). The TG curve is generally smooth with gentle slope downward up to temperature 580 °C, then drop suddenly showing loss of CO_2 in two stages. The first stage represents loss of CO_2 due to decomposition of dolomite, the second stage represents loss of CO_2 due to the dissociation of $CaCO_3$.

TABLE 2

Differential thermal analyses of carbonate samples of Qatrani Formation
(Weight of sample 1000 mg, Heating rate 10 °C/min.)

Sample No.	DTA curve		DTG Curve		Loss mg.
3Q	Slight end peak at	100 °C			
	Sharp & large end peak	810 °C	Sharp & large end peak	780 °C	230
	Sharp & large end peak	950 °C	Wide & large end peak	930 °C	227
38Q	Wide end peak at	140 °C	Small end peak at	120 °C	25
	Wide & large end peak	630 °C	Wide & large end peak	625 °C	98
	Sharp & large end peak	920 °C	Wide & large end peak	910 °C	191
46Q	Sharp & large end peak	795 °C	Sharp & large end peak	785 °C	210
	Sharp & large end peak	950 °C	Wide & large end peak	938 °C	233
61Q	Slight wide end peak	120 °C			
	Sharp & large end peak	780 °C	Sharp & large end peak	770 °C	210
	Sharp & very large end peak	940 °C	Wide & large end peak	920 °C	235
63Q	Double end peak	140 °C	Small end peak	120 °C	35
	Wide & large end peak	610 °C	Wide & large end peak	600 °C	155
	Slight end peak at	730—800 °C	Slight end peak	720 °C	28
	Large & sharp end peak	900 °C	Wide & large end peak	890 °C	140
72Q	Slight end peak	110 °C			
	Wide & large end peak	670 °C	Wide & large end peak	660 °C	205
	Slight end peak	780 °C	Slight end peak	778 °C	35
	Sharp & large end peak	935 °C	Wide & large end peak	922 °C	195
73Q	Sharp & large end peak	790 °C	Sharp & large end peak	787 °C	100
	Sharp & large end peak	940 °C	Wide & sharp end peak	910 °C	79
76Q	Wide end peak	630 °C	Wide end peak	620 °C	138
	Sharp & large end peak	820 °C	Sharp & large end peak	815 °C	108
	Sharp & large end peak	940 °C	Wide & large end peak	910 °C	142

Magnesite—Calcite—Dolomite association

Represented by *Fig. 2* for sample No. 72Q. This association shows large amounts of magnesite (38.95%) and calcite (37.07%) and small amount of dolomite (14.36%).

The T curve is generally smooth with gentle slope with slight concavity at 650 °C reflecting the dissociation of magnesite and large concavity at 940 °C indicating the decomposition of $CaCO_3$. The DTA curve shows three endothermic peaks. The first is large at 670 °C for the decomposition of free magnesite. The second peak is small at 780 °C corresponding to the dissociation of dolomite. The third is large and sharp at 940 °C corresponding to the dissociation of $CaCO_3$ as free calcite and that resulting from the decomposition of dolomite. The DTG curve shows similar peaks as DTA curve but at lower temperature (660°, 775°, 925°C respectively).

The TG curve is generally smooth with gentle slope downwards up to 460 °C and shows loss of CO_2 in three stages. The first stage indicates loss of CO_2 due to decomposition of magnesite, the second stage due to dissociation of dolomite and the third stage due to the decomposition of $CaCO_3$.

Gypsum—Magnesite—Calcite association

This association represented by sample No. 63Q in *Fig. 2*. The calcite and magnesite forms the major constituent of this association. Also, it is distinguished by the presence of gypsum in considerable amounts (11.47%—17.21%).

The T curve is smooth with gentle slope except for slight concavities at 620 °C and 920 °C due to the decomposition of magnesite and $CaCO_3$ respectively.

The DTA curve shows four endothermic peaks. The first is double peak at 140 °C characteristic for gypsum. The second is large at 610 °C due to decomposition of magnesite. The third is smooth and at 750 °C representing dissociation of dolomite. The fourth is sharp and large at 940 °C representing the dissociation of $CaCO_3$.

The DTG curve shows similar peaks as DTA curve but at lower temperature.

TABLE 3

X-ray powder diffraction data of sandstone α-quartz
(Sample: 50 Q)

d (Å) ASTM	*d*(Å) Observed	I ASTM	I Observed	*hkl*
4.260	4.277	35	35	100
3.343	4.344	100	100	101
2.458	2.460	12	14	110
2.282	2.284	12	11	102
2.237	2.242	6	6	111
2.128	2.133	9	10	200
1.980	1.985	6	7	201
1.817	1.821	17	15	112
1.801	1.812	<1	<1	003
1.672	1.678	7	7	202
1.659	1.661	3	3	103
1.608	1.609	<1	1	210
1.540	1.545	15	15	211
1.453	1.451	3	3	113

TABLE 4

X-ray powder diffraction data of dolomite
(Sample: 46 Q)

d(Å) ASTM	d(Å) Observed	I ASTM	I Observed	*hkl*
4.030	4.052	3	3	101
3.690	3.713	5	8	012
2.896	2.903	100	100	104
2.670	2.680	10	9	006
2.540	2.542	8	7	015
2.405	2.413	10	13	110
2.192	2.195	30	43	113
2.066	2.072	5	5	021
2.015	2.022	15	22	202
1.848	1.852	5	12	024
1.804	1.809	20	26	018
1.780	1.790	30	31	116
1.567	1.570	8	5	211
1.545	1.547	10	8	122
1.490	1.497	1	1	1010
1.465	1.467	5	7	214
1.445	1.446	4	5	028

TABLE 5

X-ray powder diffraction data of calcite
(Sample: 46 Q)

d(Å) ASTM	d(Å) Observed	I ASTM	I Observed	*hkl*
3.860	3.863	12	8	102
3.035	3.038	100	100	104
2.845	2.847	3	3	006
2.495	2.494	14	12	110
2.285	2.285	18	18	113
2.095	2.095	18	16	202
1.927	1.927	5	6	204
1.913	1.913	17	18	108
1.875	1.875	17	18	116
1.626	1.627	4	3	211
1.604	1.605	8	7	212
1.587	1.588	2	2	1010
1.525	1.527	5	4	214
1.518	1.519	4	3	208
1.510	1.509	3	2	119
1.473	1.473	2	2	215
1.440	1.441	5	5	300

TG curve shows losses in four stages. The first is that a loss of held water in gypsum. The second stage represents loss of CO_2 due to dissociation of magnesite. The third stage shows loss of CO_2 due to decomposition of dolomite. The fourth stage indicates loss of CO_2 due to dissociation of $CaCO_3$.

The x-ray study of representative samples of sediments of Qatrani Formation shows that the sandstone consists mainly of quartz with some kaolinite. All carbonate

X-ray powder diffraction data of kaolinite
(Sample: 70 Q)

d(Å) ASTM	d(Å) Observed	I ASTM	I Observed	*hkl*
7.170	7.178	100	100	001
4.478	4.473	35	80	020
4.366	4.368	60	70	$1\bar{1}0$
4.186	4.180	45	60	$11\bar{1}$
4.139	4.140	35	34	$1\bar{1}\bar{1}$
3.847	3.848	40	40	$02\bar{1}$
3.745	3.747	25	25	021
3.579	3.588	80	70	002
3.376	3.384	35	34	111
3.155	3.165	20	20	$11\bar{2}$
3.107	3.116	20	20	$1\bar{1}\bar{2}$
2.754	2.774	20	20	022
2.566	2.564	35	50	$1\bar{3}0,20\bar{1}$
2.553	2.553	25	40	130
2.535	2.538	35	36	$13\bar{1}$
2.495	2.500	45	45	$1\bar{3}1,200$
2.385	2.392	25	22	003
2.347	2.355	40	40	$20\bar{2}$
2.338	2.337	40	42	$1\bar{3}1,11\bar{3}$
2.293	2.273	35	30	131
2.253	2.256	20	22	$13\bar{2}$
2.197	2.198	20	14	$1\bar{3}\bar{2}$
2.186	2.187	20	14	$201,2\bar{2}0$
2.133	2.129	20	16	$02\bar{3}$
2.064	2.036	20	10	$2\bar{2}\bar{2}$
1.997	1.994	35	34	$20\bar{3}$
1.987	1.982	35	32	$1\bar{3}2$
1.974	1.976	20	14	$2\bar{2}1$
1.952	1.954	20	16	221
1.939	1.946	35	20	132
1.921	1.927	20	14	$1\bar{1}3,04\bar{2}$
1.897	1.899	25	20	$13\bar{3}$
1.870	1.868	20	16	042
1.845	1.857	25	20	$1\bar{3}\bar{3}$
1.838	1.841	35	30	$202,22\bar{3}$
1.810	1.808	20	14	$11\bar{4},2\bar{2}\bar{3}$
1.789	1.794	25	20	004
1.710	1.731	25	22	$2\bar{2}2$
1.689	1.697	25	22	$24\bar{1}$
1.681	1.685	25	22	$150,15\bar{1}$
1.669	1.672	40	40	$2\bar{4}0,20\bar{4}$
1.660	1.661	40	30	$1\bar{3}3,240$
1.649	1.653	40	30	$3\bar{1}\bar{2}$
1.633	1.628	30	24	$3\bar{1}0,24\bar{2}$
1.620	1.621	70	60	$1\bar{5}1,133$
1.607	1.614	30	24	$2\bar{4}\bar{2},043$
1.586	1.592	60	30	$13\bar{4}$
1.553	1.556	30	24	$2\bar{2}4$, 241
1.545	1.542	40	36	$1\bar{3}4,3\bar{1}3$
1.537	1.538	40	36	203
1.489	1.489	90	40	$33\bar{1},3\bar{3}\bar{1}$

sediments contain dolomite. The x-ray peaks of calcite and dolomite minerals, constituting the main composition of carbonate sediments and quartz of sandstone are narrow and sharp, suggesting good crystallinity. The x-ray data of mineral constituents of Qatrani Formation are given in Tables 3, 4, 5 and 6 and they are consistent with literature data.

The microscopic study of mineral constituents of sediments of Qatrani Formation is in a good agreement with x-ray powder diffraction study and differential thermal analysis.

CONCLUDING REMARKS

From the above study of the dolomite samples from the Qatrani Formation, the following evidences and observations can be seen:

1) The dolomites are generally finely micrograined, micrite (*Plate I—II, 1, 3* and *5*).
2) Commonly aphanitic to finely crystalline, with uniform texture (*Plate I—II, 2, 4* and *8*).
3) Most of them are brecciated (*Plate I—II, 3—5* and *8*).
4) Most of them have admixed clay and fine silt.
5) Associated with anhydrite and gypsum bands.
6) Some of the carbonates are interfingered with gypsum, sample 38Q, 63Q *(Plate II, 6—7)*.
7) Contain no relic limestone textures.
8) All the formation are red shales, sandstones, and siltstones with the dolomite interbedded bands.

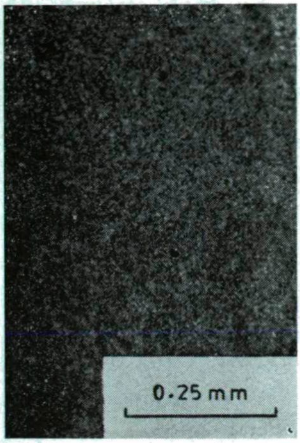
LEIGHTON and PENDEXTER [1962], BISSEL and CHILINGER [in CHILINGER *et al.* editors, 1967] considered a genetic origin for the dolomite for the above evidences.

Most of the Qatrani dolomites are associated and interbedded with evaporite sediments, typically of very fine-grained show uniform texture, lack obvious textural features that indicate origin by replacement of $CaCO_3$ sediments. Such dolostones indicates a primary origin by many authors [TARR, 1919; CLOUD and BARNES, 1948; COOPER, 1956; DUNBAR and RODGERS, 1957; KRYNINE, 1957; ILLING, 1959; HAM, 1966, and others].

COOPER [1956] considered the Knox dolostones of the Cambro-Ordovician rocks in the central Appalachian of Virginia, U.S.A., as primary in origin. Because the formation lacks limestones and includes beds of chert and numerous interbeds of quartz sandstones, a similar condition that were observed in the Qatrani Formation.

BISQUE and LEMISH [1959], recorded direct correlation of higher proportion of dolomite with greater insoluble contents in the Cedar Valley Formation (Devonian) of Iowa. A similar characteristics are postulated from the present study. The same relationship between dolomite and insoluble content was found by CHILINGER [1956], MURRAY [1960] and SCHMIDT [1964].

WEBER [1964], discussed the relationship between the water soluble chloride and the environmental conditions, he concluded that rocks deposited under marine condition must contain more than 35 ppm chloride ion. The Qatrani dolomites contain high amount of soluble chloride ions ranging from 308—6000 ppm (see Table 1), which indicates a higher water salinity of probably lagoonal conditions and the occurrence of evaporites.



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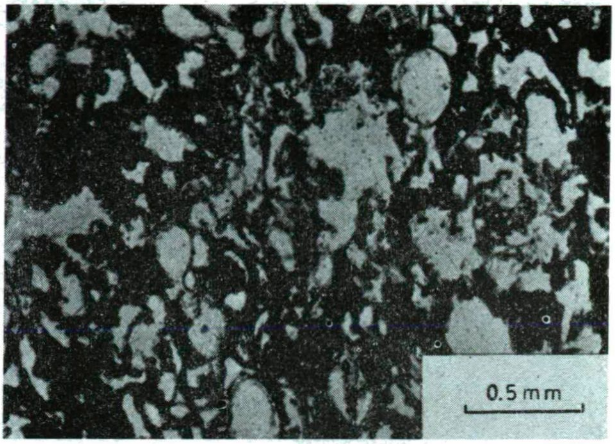

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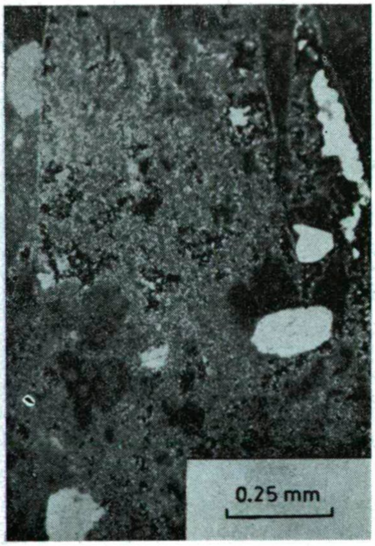

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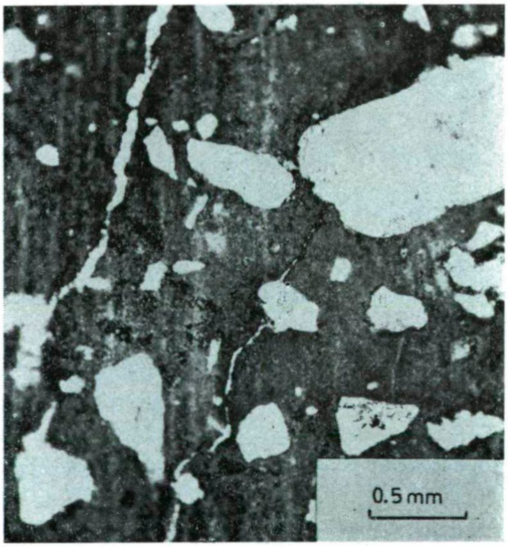

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EXPLANATION OF PLATES

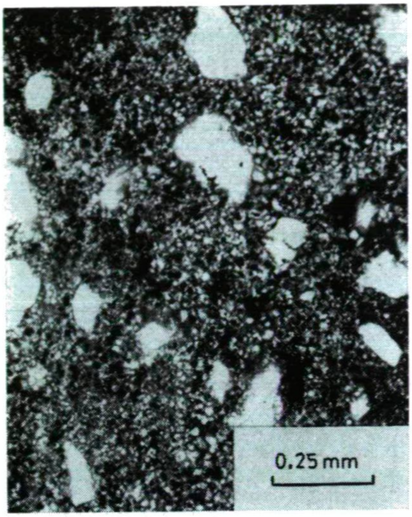
Plate I

1. Microcrystalline dolostone (dolomicrite), consisting of microcrystalline dolomites of uniform texture. Sample 3Q, Qatrani formation, Oligocene.

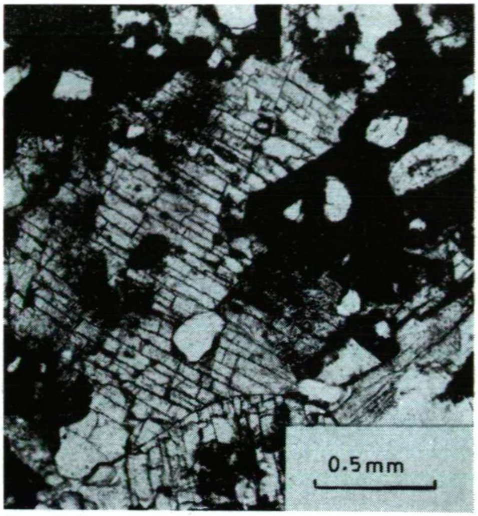
2. Microcrystalline dolostone (ostracodes dolomicrite), consisting of microcrystalline dolomites, deeply iron-stained originally; with abundant ostracodes tests, filled with dolomicrites secondary after micrite.The unstained ostracode tests are clearly deposited after the formation of the original rock-mother the dolomites.Sample 46Q, Qatrani formation, Oligocene.

3. Microcrystalline dolostone (sandy dolomicrite), consisting of microcrystalline primary dolomites. Fine-grained dolomites is a diagenetic after the primary dolomicrite. Sample 61Q, Qatrani formation, Oligocene.

4. The same. Rock shows considerable porosity, sample 72Q, Qatrani formation, Oligocene.



5



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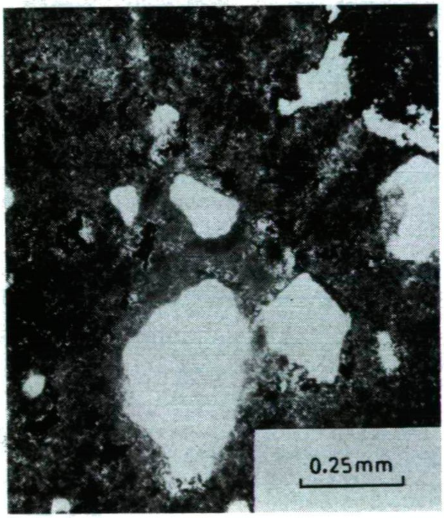

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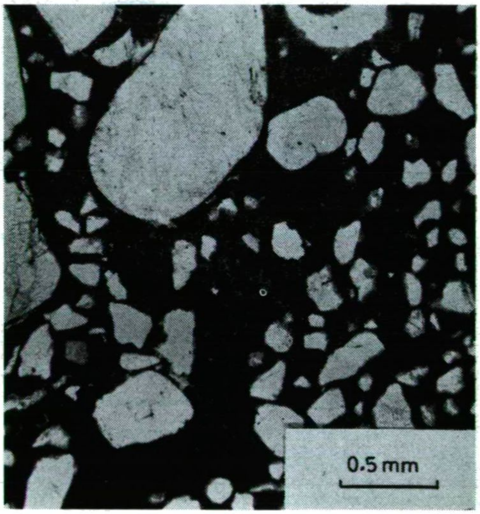

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PLATE II

5. Crystalline dolostone (sandy dolosparite), consisting of very fine crystalline dolomite rhombs (idiotopic dolomite), deeply iron-stained, with abundant angular to subangular, coarse-grained quartz, sample 76Q, Qatrani formation, Oligocene.
6. Gypsiferous calcitic magnesite, consisting of microcrystalline, undifferentiated calcitic magnesite interlaminated and intermixed irregularly with gypsum. Hematitic materials are abundant. Sample 38Q, Qatrani formation, Oligocene.
7. The same, with abundant, coarse angular quartz grains. Sample 63Q, Qatrani formation, Oligocene.
8. Dolomitic sandstone, consisting of abundant, angular to subrounded, ill-sorted (size ranging from 0.02 mm. to 20 mm.) quartz detrital grains in a microcrystalline dolomites, partly iron-stained. Sample 73Q, Qatrani formation, Oligocene.

This conditions are more favorable for the formation of syngenetic dolomites.

From the above discussions, it can be concluded that the dolomites of Qatrani Formation may be probably of primary origin. The observed characteristics of Qatrani dolomites are consistent with the literature evidences of those of primary origin.

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