

**CHAPTER THREE**

**FIELD OBSERVATIONS OF RAS**

**SHUKEIR RECENT**

**COASTAL SABKHA - GULF OF**

**SUEZ**

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### FIELD OBSERVATIONS OF RAS SHUKEIR RECENT

#### COASTAL SABKHA - GULF OF SUEZ

##### **1. Introduction:**

The supratidal coastal sabkha at Ras Shukeir area is situated on the western side of the Gulf of Suez and covering an area of about 78Km<sup>2</sup> (19.5 Km long and 4Km wide) (Fig. 23). The sabkha area is flat, elongated strip of land bounded from the north and from the west by Miocene hills and from the south by relatively elevated older analog (Fig.24A). The area is semi restricted, being protected by the basement complex highs from the west and a sort of hydroseal fence displayed by the asphaltic road to the east. To the south, a distinctive sequence of crystalline evaporite with height of about 10-15 m representing the older analog is met with. This gives a conclusive clue concerning prevalence of earlier higher sea level compared with the present.

The prevailing climatic characteristics of the area briefs that it is arid to subtropical with average maximum temperature of 37.5C° (in summer) and average minimum temperature is 11.8C° (in winter). The main evaporation rate is estimated to be about 13.9 mm/month (Egyptian Meteorological Authority1984). The average rainfall is less than 30mm/year with occasional flooding of wades occurs in winter, while relative humidity varies between 43 and 55 % (Egyptian Meteorological Authority, 1984).

##### **2. Morphology:**

The supratidal sabkha is flat and barren area except for scattered halophytes of *Tamarix Sp*, which is capable to grow in saline environments (Fig.24A). The following wades are dissecting the area from the east to the west: W.Khreim, W.Umm Yesar, W.Gharib, W.Khur El

Uyun, W.Khur Ghareirib and W.Graf (Fig.24B). The mentioned wades represent the main drainage system pouring and discharging the transported load downward all the way to the Gulf of Suez.

The surface is covered with weathered sediments, mostly composed of fine-grained terrigenous materials with disseminated interstitial gypsum crystal at shallow depth and salt interbedded with friable clay and silt. These sediments are capped and cemented with salt crust formed mainly of gypsum and halite.

Topographically: The sabkha area can be subdivided into three zones of different relative elevations. Each zone has its own sedimentological regime (sequence, facies, mineralogy and sedimentary structures, Fig.24B). These zones are:

- Zone- I: outer marginal rim, is the highest
- Zone- III: central intermediate zone
- Zone- IIII: lowest zone (hypersaline pools)

### 2.1. Outer Marginal Elevated Zone (Zone- I)

Zone-I occupies the outer rim of the sabkha, relatively the highest one (Fig.24B) characterized by its complete dryness character during the summer and partially wet during winter. This zone is barren due to infrequent rains but completely covered by tepee sedimentary structure (Fig.26). This structure occupies the top surface position, forming dissected polygons of benta to heptads in number. The height of tepee vary between 30-50 cm and magnitude increases toward the elevated and more dried part forming as megaripples with a hard veneer of crystalline salt covering the surface of tepee (Fig.27). Beneath the inverted V-shaped of the thrust tepee there is a hallow floor or loose clastics underlined by hard salt cemented clastic layer reaching a thickness of about 15cm. The name of tepee was introduced by Adams and frenzel,

1950 due to their resemblance to American-Indian tent but the mechanism and origin of the tepee structures was discussed by many authors, among of them Artjuskov, 1963; Shinn, 1969; Butter, 1969; Evany, 1973 and Shearman, 1978. They suggested that the origin of the tepee structures resulted from the instability between the underlying wet layer and overlying riding zone. Shearman, 1978 explains the mechanism of formation to be caused by lateral pressure due to continued growth of the pyramidal hopper salt crystals within the upper most crust, which will cause the sheet to break, and to buckle giving this inverted V-shaped structure.

The lithologies of the examined subsurface (shallow deep) cores are illustrated through the profile crossing C1, C3, C4, C5 and C6 (Fig.23). The profile covers the encountered sedimentary facies, mainly of clastic sequence with disseminated gypsum (partially altered to anhydrite) and halite crystals. The organic matter is present as disseminated material and/or very fine and thin black organic lamina occurred and indicates the high biological activity and organic productivity of these sediments deposited in evaporitic environments (Figs.25A-25E). These features were proved positive reaction upon testing with  $H_2O_2$  droplets on the freshly examined specimens. The sedimentary facies consists of fine to medium sand, silt with interstitial gypsum crystal in the upper part and thin greenish grey. Organic rich material, as saprobes, supporting the organic richness with thick fine to medium gypsum crystals at the bottom part was detected.

## 2.2. Intermediate Central Zone (Zone-II):

This zone occupies the central part of the sabkha between the zone of permanent of saline pools and Zone-I (outer elevated Zone), Fig.24B. The intermediate zone is characterized by the presence of gypsum mounds and mud mounds with small seasonal saline ponds surrounded by halophytes (Fig.28). Most of the area was covered by gypsum mound (Fig.29). Recent gypsum mounds appear as concave discs, more or less circular in shape (average diameter is 20cm) (Fig.30). The growth of gypsum crystals displays the effect of inverted pyramidal shaped (single

and/or twined) forming the Cavolli structure (Schreiber, 1984) appearance at top (Fig.31). Some of the gypsum mounds are recorded with opened crest(s) indicating lowering of the brine level (Fig.30). The organic odour and greenish color of the mineralized algal mat indicates the capabilities of the different organic species to flourish in different saline conditions. Mud mounds are of viscous, yellowish green colored clay with fine to medium sand-sized gypsum (Fig.32). Algal mat relics and mineralized algal filaments with organic odor are the main features around the saline pans These indicating flourishing algal and microbial communities within and around the margin of the saline pools as suggested by Javor and Castenholz, 1984, Friedman, 1985, such sediments (evaporite) are capable to yield hydrocarbon up on maturation.

A few small seasonal saline ponds were recorded within this central zone. Halophytes and mud mounds surround them. These mud mounds are 3 cm in diameter and are believed to be due to flushing the algal colonies suggesting the organic richness of the associated sediments of evaporitic environment. Lithologically the sediments of these mud mounds consist of two units: The lower made up of sandy gypsum with friable, salt crystal and free algal relics. The upper one is viscous, yellowish green in color with organic odour and includes algal filaments (Fig.34).

### 2.3. Permanent Saline Pools Zone (Zone-III):

The permanent saline pools zone is the lowest part of the supratidal coastal flat sabkha and completely covered with hypersaline water brines, that their level fluctuates according to the seasons. The saline pans exhibit a longitudinal pattern, trending in NW-SE direction. There are western and eastern pans along the southwestern and southeastern part of the sabkha area with a few solar ponds to north of these hypersaline pans (Figs. 23 and 24B). Generally the bottom of these hypersaline pans are covered with black, soft mud with dead halophytes roots and brine flies and organic odour which indicates the high biological activity and productivity of them which indicates the flushing the microbial bacteria in these hypersaline as suggested by Gerdes et al, 1985. The brine filling the western pan is deep red color resembling tomato due to

predominance of green algae, which were observed personally within it (Fig. 33). As suggested by Caplan, 1957, who studied the hydrobiology of Alviso salt at the southern end of San Francisco bay, the predominance of green algae (*Dunaliella* and *Stephanodiscus*) causes the brine to have this tomato soup color because of high blooms of red pigmented green algae. The predominance and flourishing of these green algae are indicating the high biological activity and great productivity of these environments.

The solar ponds are shallow 10-15 cm deep. The floor of these ponds consists of hopper salt with annual layering on flanks as well as on the floor where the alternative thin and thick layers are the products of successive winter and summer seasons. It recorded that when salt layer was removed turbidity occurs due to the fact that beneath the hopper salt crystals black mud and organic odour and root is present. The observing of organic odour is due to presence of microbial mat, which indicates the high biological activity and productivity, which influence and affect up on the yield and quality of salt extracted (Davis, 1973 and Javor, 1983).

### **3. Discussions and Evaluation:**

Ras Shukeir sabkha is divided into three zones of different elevation: an outer higher zone is covered with tepee structure, an intermediate central zone contain gypsum and mud mounds, which contains algal remains and organic odour as well as the mud mound of algal origin surround seasonal pans that suggesting and indicating the high organic activity and productivity of such evaporitic environment. The permanent hypersaline pans occupy the lowest zone. Gypsum is only sulphate mineral occurring with clastics as interstitial crystals but halite is precipitating insitu along the upper most surface of the sabkha. The water supply into the sabkha is almost entirely from the sea by seepage through the coastal sediments and never by flooding. The hypersaline pans are permanent due to a continuous and constant supply of seawater by seepages and strong evaporation lead to evaporite accumulation from concentrated brines. The

panns are different and have distinctive associations, the eastern pan is shallow but the western is deep with an evaporitic sequence of carbonate, algal mat at the margin and gypsum and halite crust. The solar ponds are in western part of the sabkha, which are shallow and produce annual layering of salt. The presence of gypsum mound with algal relics and mat and mud mound with algal mats and organic odour as well as mud mound of algal origin are forming and supporting a rich organic life and activity with high productivity such as green algae, halophytes and the red tomato soup color, which are indicators of prolific biological activity and productivity, knowing that evaporitic environments can be productive of organic matter and so hydrocarbon potentialities upon optimum maturation.

## CHAPTER FOUR

### SAMPLING AND APPLIED TECHNIQUES

This chapter summarizes the sampling and all executed analysis for the collected brine and rock samples. Analytical pathway and procedure of treatment(s) are shown on the flow chart (Fig. 35 and Table-1), while the detailed laboratory procedures and techniques are given as follows:

#### **1. Sampling:**

##### **1.1. Brine Sampling:**

The brine samples were collected from different hypersaline pools of Ras Shukeir area. The brine samples covering different profiles across each pool with respect to their depths and salinities were followed in a systematic way. The depths of the pools were measured and found with a range between 15 cm up to 7.5m. The gradient of the collected samples (24 in number) were given on the table-6. The samples were collected using vertical diving device and the depth profile is seen in figure-40. The collected brine samples were subjected to determining their chemical characteristics through determining their major cations and anions ( $K^+$ ,  $Na^+$ ,  $Ca^{++}$ ,  $Mg^{++}$ ,  $Cl^-$ ,  $HCO_3^-$ ,  $SO_4^{--}$ ,  $CO_3^{--}$ , pH, salinity and T.D.S) in addition to identification of their physical properties (Resistivity, conductivity, density and specific gravity) by using different geological techniques

##### **1.2. Core sampling:**

Core samples from off shore and on shore wells of Miocene evaporites from Gulf of Suez and Mediterranean Sea as well as shallow deep cores from Ras Shukeir recent sabkha area were selected representing different macro- and micro-lithofacies. The subsurface shallow deep cores at Ras Shukeir area were drilled along profile C1, C3, C4, C5 and C6 (Fig.23) covering the encountered defined facies as described in the previous Chapter. The shallow deep cores from

the recent sabkha were collected through hammering plastic rigid tube down to average depth of 100 cm and then the sealed and pulled out. The pipes were opened and slapped for detailed description and processing to elucidate the relative distribution of clastic, evaporite and organic component. The cores samples were subjected to petrographical, mineralogical, inorganic and organic geochemistry analysis by using the following different geological techniques.

## **2. Applied Techniques:**

### **2.1. Microscopic Technique:**

Microscopic technique was used to study the petrography of different lithofacies in order to determine their mineral constituents, diagenesis, mode of occurrences and distribution of organic material. The selected samples were prepared to study them under the petrographic polarized microscope. More than 120 thin-sections representing the described different evaporite lithofacies in the studied subsurface cores from the recent sabkha and the different wells from different areas and were prepared following the procedure described by Miller (1988).

### **2.2. Scanning Electron Microscope and EDX Techniques:**

SEM with EDX technique was used to study and to examine the structure textured of the rock constituent, diagenetic sequence and the form of the present organic material, particularly in rich organic sediments.

#### ***a. Selection of samples:***

SEM is a technique applied to illustrate the micro-fabric relation(s) of the examined samples as well as their textural (original and obliterated). Also the specimens are unlikely to be totally representative of the sample from which they are prepared. It for this reasons that it was not felt necessary to examine every sample using SEM

### ***b. Sample preparation.***

Mounting: A cube of rock 0.5 Cm was cut from the center of sample. The cube was split in half. Each half was mounted; fracture surface upper most, on aluminum stubs with Durafir glue. When the glue had hardened, the sample is then placed on the stub and stored in desiccators till further processing and/or examination after coating. The slides of each specimen were painted with silver paint.

Pre-coating: Preventing of Electrostatic charge charging the surface layer of the specimens occurs when electron unable to conducted away. A charged region is seen brightly glowing area in which eventually images loose all details. Before coating, loose particles were removed from the fracture surface by sharply tapping the stubs. Bust particles were removed by application of electrostatic charge.

Coating: The specimens were given a thin electrically conducting coating under vacuum using a sputter coater.

### ***- SEM equipment***

The used instrument in this study was a Joel sm 5300 with link energy dispersive X-ray analyzer and CL. Cathodluminescencead scattered detectors. The secondary electron image resolution is 4.5mm (SEI, 30kv, wd =8mm), accelerating voltage is 0.5 to 3kv, 0.1kv/step (26 steps) and 5 to30kv; 5kv/step (6 steps) linked with objective lens hysteresis eliminating function for selecting accelerating voltage. Electron gun filament represented by hairpin filament cartridge type; gun bias: Auto; for high accelerating voltage (2.1 to 30kv and for low Acc.V. (0.5 to 2kv), magnification display: x15 to 200.000, specimen size maximum 150mm, observation CRT: green, 9 inch for observation and photography, frame size: 135X180 mm (TV). Scanning speed: 0.27, 0.58, 2.88, 9.6 sec/frame, TV scan for observation and28.8, 86.4 sec/frame (50HZ) 24, 72 sec/frame (60HZ) for photographing and fully automated system.

### *- Quantitative X-Ray analysis:*

When the electron beam strikes the specimen the electrons penetrate the specimen and exit the atoms comprising specimen. Amongst other phenomena, this result in the generation of X-ray, which have wavelengths characteristics of particular excited atoms?. The X-ray can be detected and analyzed. This kind of analysis can only be qualitative because the rough surface of the specimen result in spurious X-ray generated by back scattering and because of differential absorption by specimen of X-ray of different wavelength. X-ray from elements lighter than sodium are so strongly adsorbed that they are not detected. The analyses are obtained from individual particles by spot.

### 2.3. XRD Technique:

XRD for the selected bulk samples were used to identify the minerals and supplemented the identification of minerals in thin section and SEM. X-ray diffraction (XRD) analysis was carried out using Phillips X-ray diffraction. The minerals identifications were according to their principal characteristics diffracted peaks. Semi-quantitative of minerals were carried on according to peaks intensity.

### 2.4. ICP Techniques:

The major Cations and Anions of the water brine samples from the studied area were measured by titration, flamphotometer and Inductively Coupled Argon Plasma optical emission spectroscopy (ICP). The obtained results including the phsical and chemical properities were listed in Table-6 . The The results of chmeical analysis were evaluated by using statistical and geological computer programs (e.g. SPSS, Rock work, Hydro Chem).

### ***a- Instrument***

The instrument used in this study SpectroFlame Modula ICP by spectroanalytical Instrument, Germany (Slickers, K., 1993).

### ***b- Method of Determining of cations and anions Concentration and Operating Conditions***

(ASTMD1976-91). For example Calcium concentration was determined as follows

1. The instrument was first calibrated on a calcium line (315.887 nm) using two different known concentrations of standard calcium solution. (Fig. 36).
2. A series of standard calcium solutions of concentrations ranging from 0 to 60 ppm were prepared.
3. Intensity of each standard was determined at the same wavelength by ICP.
4. Calibration curve was constructed using the instrument software (Fig.37).

The unknown samples were then introduced and calcium ion concentrations were determined by means of these calibration curves. All operating conditions were given in Table-2

### **2.5. Organic Geochemistry Techniques:**

The executed organic geochemistry techniques include: 1- Leco Carbon analyzer, 2- Rocky-Eval Pyrolysis and 3- Gas chromatography and Infrared Spectrometer. These techniques were used to determine and measure the TOC content, the thermal maturity and hydrocarbon potentialities of the selected core samples after preparation to conduct these analyses as follows. All these techniques were carried out in SCS Service Company.

### ***- Sample Preparation:***

Representative samples from shallow deep cores from Ras Shukeir area and conventional cores of offshore and onshore well from the studied fields are assigned a number, which is entered into a computer system to monitor sample selection and progress. Preparation techniques are directed towards obtaining clean samples, free from drilling mud and mud additives.

Washing with cold water is standard but further washing with solvent (dichloromethane, DCM) is carried out if oil based mud is present. After washing samples are dried then rough crushed to approximately pea-sized for kerogen preparation or finely milled for chemical analysis.

### ***2.5.1. Total organic Carbon Content (TOC) technique:***

Organic carbon values are obtained by treating 0.1 g of sample with hot concentrated HCl to remove carbonates. The washed residue is filtered on to a glass fiber pad and ignited in a Leco Carbon Analyzer C/S-12. For screening purposes, samples are analyzed singly but where further analysis, such as pyrolysis or solvent extractions are anticipated a duplicated sample is run. Blank and standards are run as routine and where values from duplicated samples don't concur within accuracy limits. Where samples are heavily stained with oil, either from natural deposits or drilling mud, TOC is repeated on the drilled, solvent extracted sample. TOC measurement is fundamental in assessing source rock quality since when combined with kerogen types and maturity; a full description of potential to generate oil may be given. It's found in practice that the sediments containing less 0.3% TOC are unlikely to have any source potential, those containing between 0.3 and 1% may be marginal source but better quality sources contain more than 1% TOC.

### ***2.5.2. Rocky-Eval Pyrolysis:***

Pyrolysis data are obtained using the IFP-Fina Rocky-Eval apparatus. 100mg of crushed whole rock is weighted accurately into crucible and introduced into a furnace at 250C°. Free hydrocarbons (roughly equivalent to solvent extractable hydrocarbons) are volatilized and quantified by flame ionization detector (FID) to give peak 1 (S<sub>1</sub>, ppm). The furnace temperature is increased to 550C° at 25C°/minute and within this range kerogen crack to give hydrocarbons measured by FID to give peak 2 (S<sub>2</sub>, ppm) and Carbon dioxide measured by thermal conductivity detector (TCD) to give peak 3 (S<sub>3</sub>, ppm). The temperature at maximum rate of evolution of

cracked volatiles ( $T_{max}$ ) is measured automatically but can also be monitored visually. The instrument is calibrated daily using standards both at the beginning of the work period and at regular intervals thereafter and crucible blanks are run as routine. The tabulated data in this Thesis comprise the following parameters:

**$T_{max}$  C°:** Temperature of maximum rate of peak 2 hydrocarbon evolution.

**Hydrogen Index (HI):**  $S_2/TOC$  (mg/g) or ratio of released hydrocarbon to organic carbon content. This is a measure of the hydrocarbon generating potential remaining in the kerogen as opposed to that of the whole rock.

**Oxygen Index:**  $S_3/TOC$  (mg/g) or ratio of released Carbon dioxide to organic carbon content

**Production Index:**  $S_1/S_1+S_2$  or ratio of amount of hydrocarbons released in the first stage of heating to the total amount of hydrocarbons released and cracked during pyrolysis.

**Potential Yield:**  $S_2$  (ppm) or total hydrocarbons released during cracking of kerogen compared to original weight of rock.

$T_{max}$ , HI and OI are each functions of both maturity and kerogen type. Using published and empirical data, it has been possible to assemble a model to show the relationships of these factors to maturity as measured by IR and vitrinite reflectance for selected pure kerogen types. The kerogen types used are algal sapropel (type I), Waxy sapropel (type II), Vitrinite (Type IIIA) and inertinite (type IIIB) and a computer program has been devised by which the amounts of these components may be calculated from HI, OI,  $T_{max}$  and maturity data for any sample. These are values expressed in the kerogen composition by calculation (column tabulated) in this work.

### **2.5.3. Bitumen Extraction:**

Traditional Soxhlet extraction with  $CH_2Cl_2$  is time consuming (24-48 hrs) and large amount of organic solvent must be evaporated. This often causes losses of the light *n*-alkanes. Also, asphaltene/non-asphaltene fractionation and column chromatography are very time-

consuming methods. These processes have been replaced  $\text{CH}_2\text{Cl}_2$  extraction by ultrasonic agitation and centrifuging. A few grams of the pulverized (dust) samples (depend on the TOC content) are ultrasonically treated with 30ml of  $\text{CH}_2\text{Cl}_2$  for 10 minute. After centrifuging for 4 minute at  $4000\text{ cm}^{-1}$  and decanting of the solvent, the treatment is repeated at least times to remove all soluble bitumen until the liquid remain clear. The bitumen is collected in lab beakers slightly covered with aluminum foil and placed under hood in order allow slow evaporation of solvent. The extracted sediment is transferred in 100 ml plastic tubes of centrifuge and is ready for HCl/HF treatment of kerogen isolation. After drying, the beakers re-weighted in order to calculate the weight of extracted bitumen, and then the extracted bitumen is transferred to small 5ml vessel for analysis.

#### ***2.5.4. Kerogen Isolation:***

The residue, after extraction of bitumen, is transferred into plastic tubes, some drops of methanol are added in order enhance their wettability. The residues were treated with (HCl and HF) as described by Foreman and Hunt, 1958 and Ganz et al 1990. The residue treated with HCl (10%) in order to destruct carbonates. The solution is decanted after centrifuging and the sample is treated with conc. HF (about 15ml/40%). In order a good suspension, the mixture is stirred carefully. The plastic tubes are placed in water bath at  $70\text{C}^\circ$  for about 3 days, each day the tubes are filled up with additional HF. The solution is decanted after centrifuging and treated with hot HCl (20%) to remove fluorides that might have formed during the solution of minerals. After HCl treatment, the samples are washed twice with hot distilled water and dried after decantation at  $60\text{C}^\circ$  in an ordinary laboratory oven. Ganz, 1986 indicates that the hot acid treatment and drying at elevated temperatures for limited times doesn't influence the composition of kerogen. After drying, the kerogen is ground by hand in an agate for 2 minutes. The kerogen is ready now for IR analysis.

### 2.5.5. IR- Analysis:

Infrared Spectroscopy (IR) is applicable method to kerogen study example (Robin et al 1977; Rouxhet et al, 1980). Also the evolution of kerogen structure during burial is reflected in the infrared spectrum (Tissot et al, 1978). In this work the IR used to determine and evaluated the kerogen types was carried out insitu. The pellets are prepared by mixing 0.4-0.5mg of isolated kerogen with 200mg KBr and carefully homogenized. The pellets are dried under vacuum at 90C° for 4 hrs in oven to insure their complete dehydration before analysis then scanned. The spectral display distinctive peaks at 2860 and 2930 cm<sup>-1</sup> (CH<sub>2</sub> and CH<sub>3</sub> aliphatic groups respectively) and at 1710 cm<sup>-1</sup> (Carboxyl and Carbonyl group) and at 1630 cm<sup>-1</sup> (aromatic C=C bands). With increasing maturation, aliphatic peaks initially decrease while there is no apparent change in the peaks representing the aromatic C=C bands (Ganz *et al*, 1987). The relative intensities of aliphatic, carbonyl, carboxyl and aromatic peaks (A and C factors) were used to classify the kerogen (ganz, 1978) into different types on cross plot similar to van krevelen diagram (Tissot and wellte, 1984; Ganz and Robison, 1985, Ganz, 1986) where A and C-factors are replaced the pyrolysis hydrogen index (HI) and oxygen index (OI).

$$\text{A-Factor} = \frac{2930+2860 \text{ cm}^{-1}}{2930+2860+1630 \text{ cm}^{-1}}$$

$$\text{C-Factor} = \frac{1710 \text{ cm}^{-1}}{1710+1630 \text{ cm}^{-1}}$$

IR-diagram (Fig.38) was developed in order to determine thermal maturity by means of vitrinite reflectance equivalent which allows precise determination of Ro% Ganz et al, 1987. A-factor, measured from IR-spectrogram, had also used to define the hydrocarbon potential of the organic rich rocks by means of A-Factor X TOC X 10.

### 2.5.6. Gas-Chromatography (GC):

“GC” is a common technique used to separate and identify compounds in bitumen and petroleum. This technique used in this study and carried out in SCS service Company. The

samples were injected into the column under stream of carrier gas (example helium), partitioning occur between the gas and hydrocarbon gases. As molecules pass out of other end of the column, they are detected. Samples were injected into Perkin Elmer GC 3A chromatographs equipped with a fused silica capillary column coated with RSL-150 (30m length, 0.5mm I.D. and 0.25 $\mu$ m film thickness) and temperature programmed from 80-300C° at 20 C°/min. Injection was performed in the split mode and injector and detector temperature were held at 320C°.

C<sub>15</sub><sup>+</sup> chromatograms are inspected for the distribution of n-alkanes and the presence and absence of isoprenoids (particularly pristane and phytane), steranes and triterpanes and unresolved envelopes of naphthenic compounds. The ratios pristane: phytane and pristane: n-C<sub>17</sub> with phytane: n-C<sub>18</sub> is calculated. Carbon preference index (CPI) values quoted at those as defined by Philippi as the ratio 2C<sub>29</sub> to (C<sub>28</sub>+C<sub>30</sub>) unless otherwise stated. Chromatography may reveal information about the kerogen type of the source rock, its maturity and condition of deposition and if migrant oil is present, whether this has been water flushed or biodegraded. Contaminant drilling mud additives may be identified.

## 2.6. Fluid Inclusion Analysis Technique:

During crystal growth, small droplets of mother solutions were trapped intracrystalline cavities of the crystal: It called fluid inclusion. The study of these fluid inclusions gives significant indication of salinity and chemical characteristics of the mother inclusion and also hydrocarbons presence.

For fluid inclusion study in this present work, millimeter size fragments of Evaporites (Gypsum, Anhydrite and Halite) were obtained by cleaving the crystals along the perfect (010) cleavage plane, the Petrographic characteristics of fluid inclusion (size, shape, abundance and distribution) within the cleavage fragments of evaporites were studied under the Petrographic Microscope prior to analysis by using magnification 400X.

Micro thermometer was used to study the freezing/melting behavior of the fluid inclusions. Melting temperatures of the solid phases can help the determination of the chemical composition and salinity of the liquid trapped in aqueous inclusion (Roeder, 1972 and 1984; Hans, 1985). The freezing/melting behavior of fluid inclusions in millimeter-size cleavage fragments of Gypsum, Anhydrite and Halite crystals were observed using a Fluid Inclusion unit adapted USGS Gas flow heating/Freezing stage mounted to a Petrographic Microscope. This analysis was carried out in Cairo University. Observations were made at magnification of 400X under Microscope. One-phase (liquid) inclusions and two-phase (liquid and solid) inclusions were recognized. Putting the sample in a refrigerator for a week produced vapor bubbles in single-phase aqueous inclusions. The volume increase upon freezing caused the inclusions to stretch, leading to formation of a vapor bubble that persisted at room temperature as well as during subsequent freezing runs. Vapor bubbles formed in this way by stretching ensure equilibrium behavior during melting of frozen inclusions and avoid errors in determining ice melting temperatures due to metastable superheated ice and "over expanded liquid" (Roeder 1984, P.295-302 for full discussion). Super cooling to temperatures between  $60^{\circ}\text{C}$  to  $90^{\circ}\text{C}$  then froze fluid inclusions. The frozen inclusions were then heated  $1-2^{\circ}\text{C}$  per minute and the melting temperatures of solid phases formed during freezing were recorded. Slower heating rates, approximately  $0.3^{\circ}\text{C}$  per minute, were used near temperatures of phase disappearance. The first melting temperature of fluid inclusions ( $T_e$ ) and the final melting temperature of ice ( $T_i$ ) were recorded. The final ice melting temperatures enable calculation of fluid inclusions salinities and hence parent brine salinities using equation of Potter et al (1978). The final melting temperature of ice was recorded to within  $0.1^{\circ}\text{C}$  and was reproducible to within  $\pm 0.2^{\circ}\text{C}$ , thermocouple accuracy was  $\pm 0.1^{\circ}\text{C}$  over the interval investigated ( $0^{\circ}\text{C}$  to  $-40^{\circ}\text{C}$ ).