Songklanakarin J. Sci. Technol.
31 (6), 655-660, Nov. - Dec. 2009

Songklanakarin Journal
of Science and Technology
http://www.sjst.psu.ac.th

Original Article

Lithological and petrophysical evaluation of the caprock keybeds, Asmari Reservoir of Pazanan Oil Field, Zagros, Iran

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Received 28 September 2007; Accepted 9 January 2009

Abstract

The Pazanan oil field is located 150 km SE of ahvaz city in SW of Iran and measures 60 km long, 4-6 km wide. The caprock of this oil field were evaluated using well logs (gamma-ray and sonic logs) SEM and petrographical microscopy data. The cap rock consist of mudstone, interlayers of anhydrite and bitumens shale. Therefore, it can be classified as mudstone type. On the basis of our investigations, the Caprock can be divided in to 6 keybeds: A(Anhydrite), B(Bitumen shale & some times bitumen marls), C (mudstone with interlayers of shale & anhydrite), D (mudstone & anhydrite), E (mudstone) & F(mudstone & packstone), almost all of these units coverd by salt. Anhydrite beds show the following textures: microlitic, spherolite, porphyroblast, and granular. Anhydrite crystals indicate the occurrence of processes such as emplacement and calcitization. Sonic and gamma-ray well logs were used to determine lithological changes. The highest peak is correlated with mudstone units. Caprock depth varies from 2580m(min)-2717m(max) [northern part], 1704(min.) - 2444 (max.) [central part],

And 2050 (min.)- 2490 (max.) [southern part] using well drilling data. It seems that that the thickness in the southern part is less than is other part. Comparing the thicknesses of different keybeds. The maximum occurs in the c-keybeds. The sedimentar : sequence of Caprock started by mudstone, packstone and interlayers of anhydrite, followed by mudstone, anhydrite, shale-marl, as well as bitumen shale, mudstone and anhydrite and finally was overlaid by salt. Lithological variation indicate a sabkha-lacustrine environment. Therefore, the hot-wet and hot-dry climate was dominated. In some cases, Caprock thickness decreases to 6m without any gap. This thinning is related to structural deformation. Unfavorable lithology conditions resulted is well collaps.

Keywords: caprock, key bed, SEM, bitumen shale

1. Introduction

The caprock, the most important part of the petroleum play must be considered in drilling, production and reservoir evaluation. Compared to the enormous literature devoted to reservoir rocks, and the massive effort devoted to understanding the geochemistry of source rock, virtually nothing has been written on caprocks, such as mechanics of secondary migration and sealing (Schowalters, 1976), the effect of hydrodynamics and over pressure in Powder River basin, Wyoming (Berg, 1975), in the Niger delta (Weber *et al.*, 1978) and Gulf coast (Downey, 1984 and Grunau, 1987), loss of petroleum through cap rock by diffusions (Leythaeuser *et al.*, 1982), compile lithologies 25 largest oil and gas fields (Grunan, 1987). caprock is, however, considered the it is a top seal, while in Iran, it is also responsible another important task between two under pressured layers. The aim of this study is the evaluation of the cap rock in the Pazanan oil field in view of lithology and chemical variations. It may offer new insight into the regional distribution of caprock.

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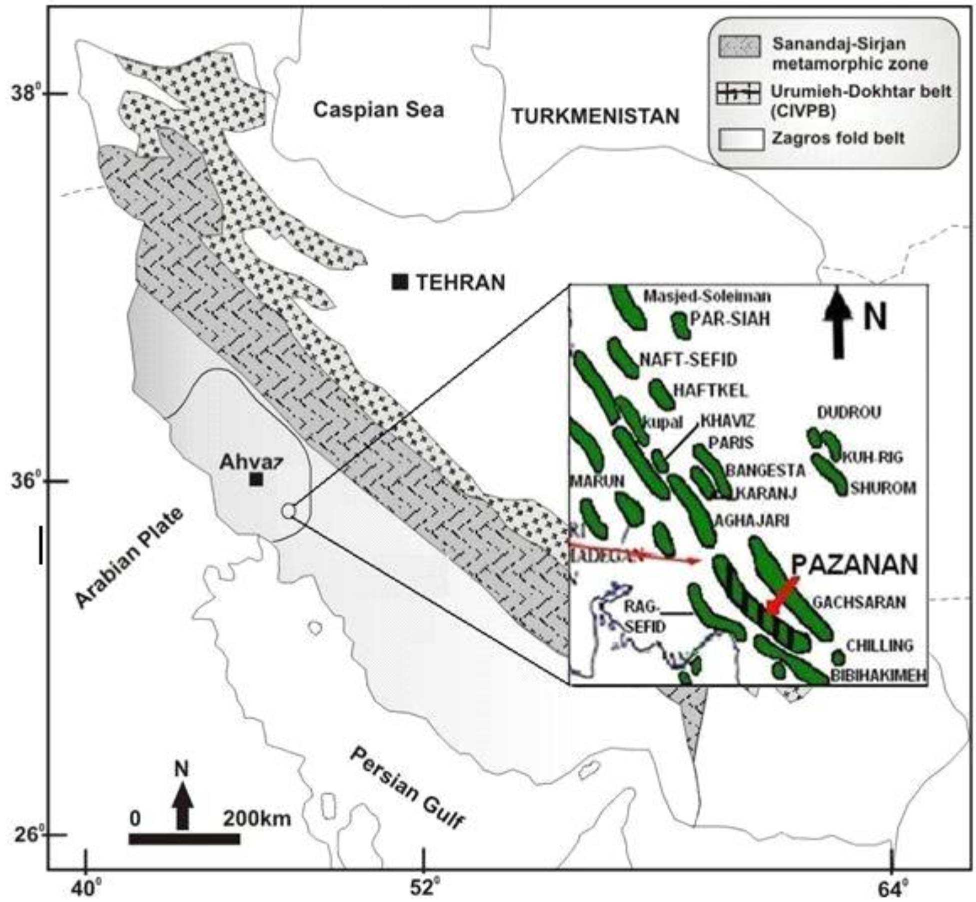

Figure 1. Geological and geographical location of Pazanan oil field, south west of Iran.

In this way, we:

1) determined the mineralogy and textures.

2) determined the characteristics of key beds behavior against gamma-ray and sonic logs.

3) used mineral characteristics and composition to get a view of mineral reactions and provide a new scope of mineralization.

2. Geology

The Pazanan oil field (Figure 1) is one of the Zagros oil fields is located 150 km SE of Ahvaz city in SW of Iran and measures 60 km long and 4-6 km wide. It is an asymmetrical anticline which is a large inverse fault defining the south flank. Asmari (Oligocene age) reservoir was capped by the lower part of Gachsaran Formation (member 1). Member 1 reaches up to 50 m thick, and was deposited in early Miocene.

3. Methodology

3.1 Sample collection

Samples for this study were collected from different depths and locations to provide a better understanding of chemical variation, distribution and definition of the key beds of the caprock.

3.2 Ordinary petrography and SEM

More than 500 thin sections were petrographically studied using advanced microscope (Olympus model BX60). Selected cutting samples were then analysed by scanning electron microscope (SEM) (model Leo 1455vp) with elemental analyzer.

3.3 Gamma-ray and sonic well logs

Gamma-ray and Sonic well logs are quick and commonly used methods for formation evaluation and in sequence stratigraphy (Davis and Elliot, 1996). To characterize and determine the lithology of caprock, the available logs were used. Also, they are used to correlate stratigraphic columns of the field (Figure 2). These logs have been supported by the National Iranian Oil Company (NIOC), south headquarters.

3.4 Sonic log

In its simplest form, a sonic tool consists of transmit-

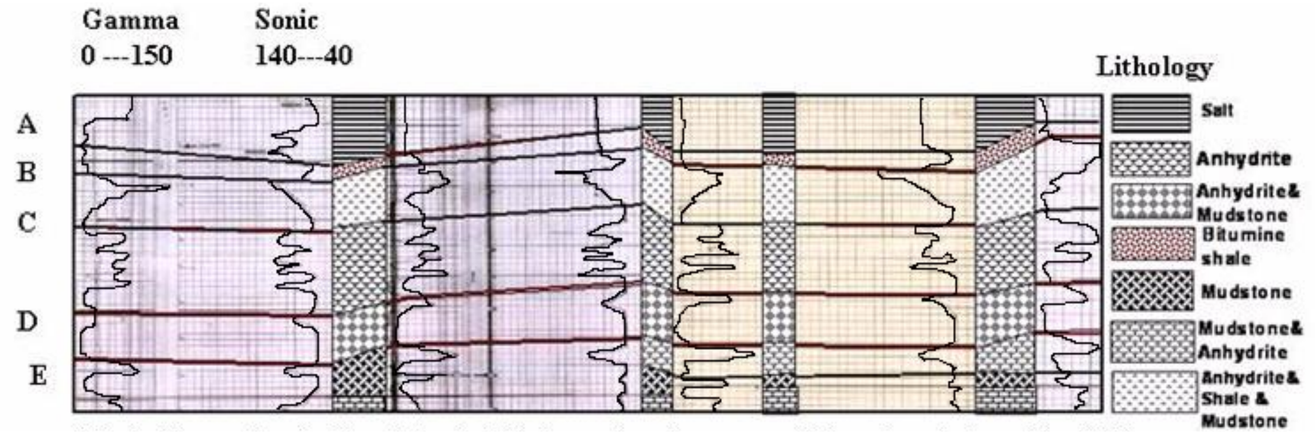

Figure 2. Gamma Ray (left) and sonic (right) well logs representing correlation of stratigraphic columns in different wells (169-165-129-152) from left to right, northern flank of Pazenan oil field.

ter that emits a sound pulse and a receiver. The sonic log is simply a recording versus depth of the time, t, required for a sound wave to traverse 1ft of formation. The interval transit time for a given formation depends upon its lithology and porosity.

3.5 Gamma-ray

The GR log is a measurement of the natural radioactivity of the formations in sedimentary formations. The log normally reflects a shale composition formation. This is because the radioactive elements tend to concentrate in clay and shale. Clean formation usually has a very low level of radioactivity.

4. Discussion

It seems to be an essential fact that each lithology type can play a role on hydrocarbon accumulation, if its pressure is more than the buoyancy pressure of hydrocarbon column. Therefore, the study of lithology, mineralogy, thickness variation, distribution and internal individual behaviors of the cap rock can be reveal its different aspects. Sonic and gamma-ray log data indicated that the caprock consisted mainly of mudstone (Figure 3).

Table 1 provides a summary of general lithological characteristics of caprock in the Pazanan oil field. Lithologically, it can be divided into 6 keybeds. These show variation in thickness from 26.5 m to 43.5 m. This variation is also

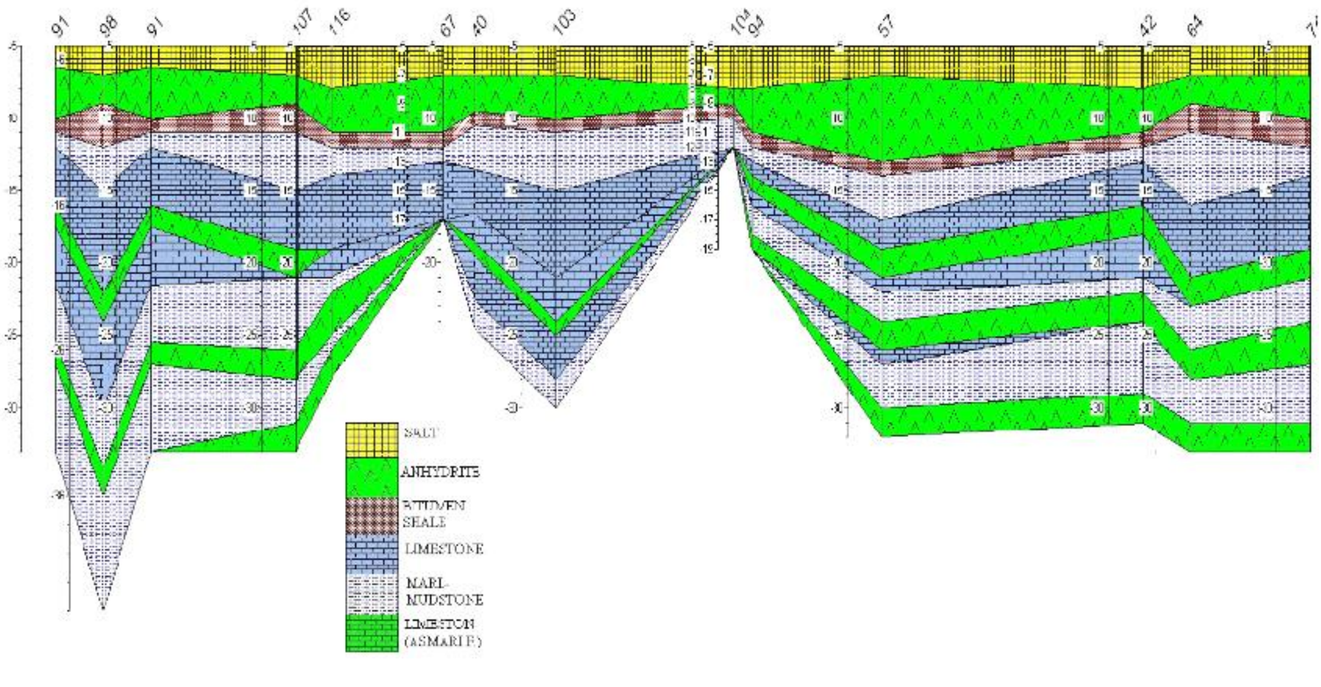

Figure 3. General stratigraphic column of the Gachsaran formation,member 1 with detail Asmari caprock keybeds in different wells of the Pazanan oil field.

Table 1. General lithological characteristics of keybeds of Asmari caprock, Pazanan oil field

Keybeds	Description
A	Anhydrite sometimes forms coarse crystals (0.5 mm long), and interlayer lime
B	Bituminous shale with mudstone, with sparse anhydrite.
C	Mudstone to wackstone with traces of bitumen and dolomite. Interspace of allochem was filled by anhydrite.
D	Mudstone is dominated. Anhydrite is a minor phase as pore filling and nodular or vein. The crystal size is up to 0.5 mm.
E	Mudstone and interlayers of anhydrite (acicular shape up to0.4mm long)
F	Wackstone, mudstone or packstone in some cases, with anhydrite as filling cast, and sparse quartz (0.08 mm in long dimension)

Table 2. The comparison of the cap rock thickness in the Pazanan oil field

Well.no	K.B/A	K.B/B	K.B/C	K.B/D	K.B/E	K.B/F	T.TM
195	1	6	15	7	5.5	4.5	39
129	…	…	…	6.7	6.1	3.4	35
132	3.7	3.9	4.9	9.7	6	5	34
170	0.25	8.75	7	12.5	4.5	4.5	37.5
193	2.25	6.75	10.75	…	…	…	26.5
116	2.1	7.9	10	5	4	7	36
103	2.25	9	13	8	4.5	0.5	37.5
164	3	10	21	…	…	…	43.5

Abbreviations: K.B = Key Bed; T.T = Total thickness

reflected on the surface structure of Pazanan anticline is that it is similar to a saddle form (normal to axis). Therefore, it can be expected that the elevation of the central part is less than that of other parts. In spite of this matter, there is no evidence of petroleum leakage at present. However, the presence of hydrocarbon traces in the caprock is possible related to ancient leakage, but this needs isotope study to confirm. In a few cases, it reaches to six meters. Nevertheless, thinning and the lack of cut off keybeds are individual characters of the Asmari caprock in this oil field.

Lithological variations from the bottom to top of the caprock markedly showed that dominate sedimentary conditions transitionally changed upward to a quiet environment (lagoon). It should be noted an important point that one can identify the bituminous shale key bed (i.e. B) in all positions of the field.

The caprock thinning (Table 2) can be related to the tectonic and structural effects. These factors, as well as lithological variation cause the well-collapse during a drilling project. In the light of petrography, the studied samples range from anhydrite, bituminous shale and mudstone. The interlayers of anhydrite show the following textures:

1- Spherolitic (Figure 4A); 2- Microlithic; 3- Granoblastic; 4- Enterolithic; 5- Porphyroblastic (Figure 4C)

The alteration of anhydrite crystals was approved using SEM analyses. This process resulted in a change of their chemical compositions (Table 3). The presence of

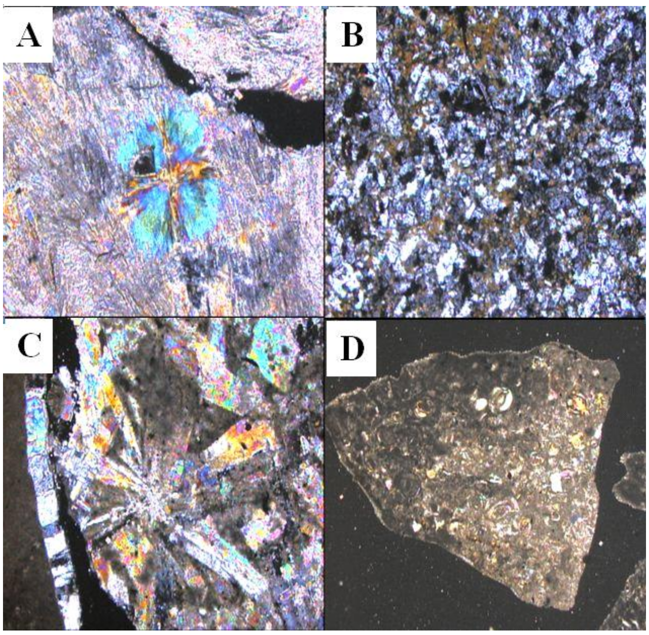

Figure 4. Select texture (polarized light). A. spherolitic B. granoblastic C. porphyroblastic D. replacement and porefilling of anhydrite-gypsum.

chemical components than calcium sulfate is due to calcitization and somehow dolomitization. Halite (NaCl) may be considered as a minor phase. However, it is a main mineral

Table 3. Chemical analyses of shale and mudstone samples

Elements	Shale	Shale	Mudstone	Marl
Na	6.15	7.89	4.51	39.97
Mg	19.17	4.73	3.88	1.16
K	1.78	3.01	0.68	…
Ca	34.69	33	33.69	…
Fe	1.04	1.36	1.86	…
Al	6.11	6.48	1.79	1.97
Si	15	21.13	10.74	2.25
S	7.24	11.48	25.66	…
C	0.69	0.85	0.59	4.27
Cl	8.14	10.07	6.97	50.39
Ba	…	…	9.64	…

Table 4. Chemical compositions of selected Anhydrite, Dolomite crystals and globular zinc

El.	Key Beds and crystals					
	C	C	E	E	F	F
	Anhy.	Anhy.	Anhy.	Anhy.	Fe-Car.	Z-Car.
Na	26.5	1.01	5.20	22	…	…
Mg	1.29	11.43	15.8	1.01	…	…
K	4.28	3.11	…	…	5.1	…
Ca	4.44	0.11	46.02	26.7	20.9	…
Fe	…	…	…	…	56.9	…
Al	3.65	51.14	…	…	4.5	…
Si	16	3.82	…	…	3.0	…
S	1.71	1.34	17.9	23.8	…	…
C	3.29	…	0.76	2.1	9.6	25.1
Cl	38.8	28.03	9	24.4	…	2.5
Zn	…	…	…	…	…	72.4
W	…	…	5.34	…	…	…

Abbreviations: El. = Elements; Anh = Anhydrite, Fe-Car. = Fe carbonate, Z-Car. = Zinc carbonate

phase in some cases and consisted more than 90% of the sample. This may be due to uneven mineral distribution at all. Any way, the mentioned processes related to the diagenetic released fluids which are rich of different cations. These fluids even could be able to solute the mudstone and in some cases, globular shape mineral (Figure 5c) containing 72.4% Zn element (Table 4) to form by the change of physico-chemical conditions. It may be also Ba up to 10% was presence in a few studied samples (Table 2).Therefore, it is suggested that the caprock should be investigated in respect of mineralization in future caprock studies.

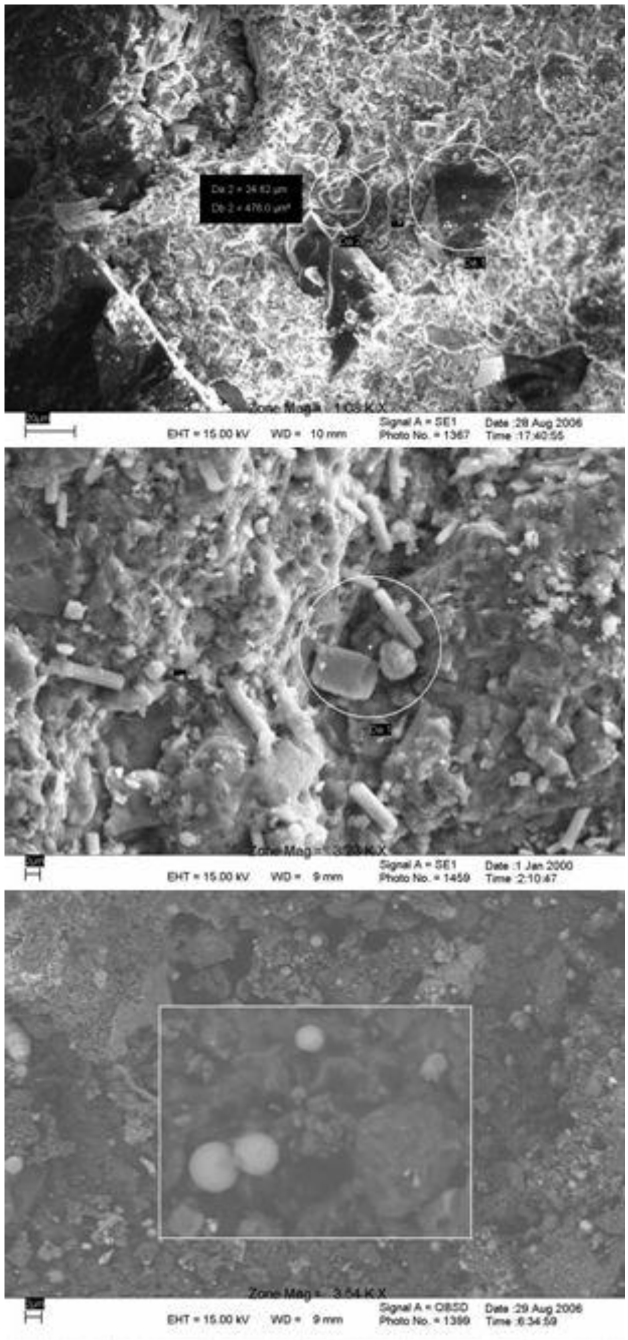

Figure 5. SEM photographs of anhydrite crystal a & b and zinc globular (c) in a mudstone-anhydrite matrix (keybed f). their compositions provided in Table 4. Scale 2 µm

5. Conclusions

Studied key beds of Asmari caprock in the Pazanan oil field presents the following results:

1. Mudstone is the dominant lithology.
2. The caprock can be divided into six keybeds: A, B, C, D, E, and F.
3. there is variation in the caprock thickness and sometimes decreases to 6 m. C-keybed shows the maximum thickness.
4. Spherolitic, porphyroblastic, enterolithic and nodular textures of anhydrite can be seen in thin sections.

5. The SEM analyses of selected samples indicated the effects of calcitization and emplacement diagenetic processes in anhydrite crystals.

6. The presence of interlayer anhydrite may be caused the flexibility of caprock during the structural deformations.

7. The lithology changes from wackstone-mudstone with interlayer of anhydrite to bituminous shale using GR and sonic well logs and petrographical observations.

8. The sedimentary sequence offered a sabkha/lagoonal environment to Gachsaran Formation.

9. Chemical composition variations of key beds demonstrated the changes is weather from wet-hot to dry-hot during sedimentation.

Aknowledgements

We are grateful of Dr. Amiribakhtiar, the head of geology department of NISOC and Dr. Zargar, Head of Instrumental Center of Shahid Chamran University, and Mr. Fazely, Officer in charge of SEM. We should also express special thanks to dear our colleague Dr. A. Zarasvandi for his critical discussions and support.

References

Berg, R.R 1975. Depositional environmental of upper cretaceouse Sussex sandstone. House Creek field Wyoming. Bulletin of American Association of Petroleum Geology. 59, 2099-2110.

Berg. R.R 1975. Capillary pressure in stratigraphic traps. Bulletin of American Association of Petroleum Geology. 59, 939-956.

Daivies, D.K. 1968. Carbonate turbidites. Gulf of Mexico. Sedimentology Petroleum Journal. 38, 1100-1109.

Downey, M.W. 1984. evaluating seals for hydrocarbon accumulations. Bulletin of American Association of Petroleum Geology. 68, 1752-1763.

Grunau, H.R. 1987. A world wide look at the cap rock problem. Petroleum Geology Journal. 10, 245-266.

Leythaeuser, D., Schaefer, R.G and Yukler, A. 1982. role of diffusion in primary migration of Hydrocarbons. Bulletin of American Association of Petroleum Geology., 66, 408-429

Schowalter, T.T 1976. The mechanics are secondary hydrocarbon migration and entrapment Wyoming Geology Association Earth Science Bulletin. 9, 1-43.

Weber, K. J., Mandle, G., Pilaar. w.f., Lehner, F. and Precious, R.G. 1978. The role of faults in hydrocarbon migration and trapping in Nigerian growth fault structure. 2643-2651. offshore Tech. Conf. Houston, paper OTC 3356.

Weber, K. J., Mandle, G., Pilaar. w.f., Lehner, f. and Precious, R.G. 1978. The role of faults in hydrocarbon migration and trapping in Nigerian growth fault structure. 2643-2651. offshore Tech. Conf. Houston, paper OTC 3356.