World Applied Sciences Journal 8 (10): 1193-1199, 2010
ISSN 1818-4952

Application of Rock-Eval6 in Detection Seepage of Yortshah Gas Storage

Tabari Khashayar

Msc in petroleum engineering. Amirkabir University. Tehran. Iran

Abstract: Gas storage reservoirs are used on a worldwide basis for the storage of natural gas for use in periods of peak consumption, generally in the colder portions of the year when gas demand for heating is higher. Yortshah aquifer is one of the reservoirs that has been considered for storing the required gas of Tehran. This structure distinguished by geophysical exploration in 1980. On the basis of geophysical data obtained in 1980, it is a faulted aquifer. The aim of this project is evaluation of geochemical feasibility of gas storage in Yortshah reservoir and determination of gas diffusion and dispersion in the upper horizons of reservoir, using geochemistry methods. For this purpose, 52 wells were drilled in surface horizons of Yortshah reservoir to the depth of 3m below ground level and 156 samples were taken from 1, 2 and 3m depths for geochemical studies. The amount of free hydrocarbons in these samples was evaluated by Rock_Eval apparatus and With the intention of identifying leakage system, variation of the amount of hydrocarbons in the samples were evaluated using three counter maps of different depths.

Key words: gas storage · Seepage · Rock-Eval · Aquifer

INTRODUCTION

Gas storage reservoirs are used worldwide to store produced natural gas during periods of low demand for future use during times of high demand. Gas storage reservoirs generally consist of good to excellent quality formations which are often located spatially close to the ultimate demand source (i.e. major population centers) [1].

One type of underground reservoirs that is used for gas storage is aquifer.

Only aquifers having conditions of natural reservoirs can store and keep injection gas. These Conditions include [2]:

- Proper Cap rock that prevents the leakage of stored gas.
- An area with high porosity and permeability. This area must also have sufficient thickness.
- Proper water layer pressure under the of gas storage area.

If the cap rock does not provide a complete seal, the hydrocarbons of the reservoir will passed through the cap rock and migrated to upper layers and surface. This leads to an increase in the amounts of free hydrocarbons in the upper horizons.

Seepage of hydrocarbon compounds from lower oil and gas reservoirs to upper horizons is a very effective tool in the identification and exploration of hydrocarbons resources and in evaluation of reservoir formations which are intended as gas or oil storage [3, 4]. Hydrocarbon compounds in reservoirs move towards the upper horizons over time, owing to the influence of different process. Hydrocarbon leakage to the upper horizons can take place via joints, faults and interconnected porosities in the upper reservoir formations structure. Concerning the surface geochemical investigations, for related studies of hydrocarbon leakage from lower reservoirs different methods and evidences can be utilized. The most significant methods are:

- Soil microbiological studies in order to identify hydrocarbon-eating bacteria. As a result of increase in hydrocarbon leakage in upper horizons, the number of certain consuming types of bacteria will increase [5, 6].
- Investigation of Ph and eh variations in soil layers [7].
- Geological studies with the aim of investigating variation in the amount of rare metal elements, ferruginous minerals, halogens in different layers, above hydrocarbon deposits and gas storage places [7].

Corresponding Author: Tabari Khashayar, Msc in petroleum engineering. Amirkabir University. Tehran. Iran

- Iron and Manganese clay mineral accumulation due to combination with organic acids present in upper reservoir layers [8].
- Increase in hydrocarbon gases immediately after reservoir top to ground level [9].
- Cementation of detrital sediments between reservoir and ground level.
- Decline of isotopic combination of carbon ä^{13}C in soil due to reaction of calcite and carbon derived from hydrocarbon materials.
- Investigation of trend of variation in surface vegetation [9].

Considering the fact that currently there is a Small amounts of hydrocarbons in reservoir in region under study, the amount of free hydrocarbons Results from the reservoir seepage in surface horizons is negligible and cannot bring about a suitable change for studying purposes. The only suitable way to study this amount of hydrocarbon is by utilizing Rock-Eval 6 pyrolyze method. This new Rock-Eval apparatus model is capable of measuring the amount of free gas both in rock and soil samples. This method as the only option for the purpose of project. Therefore To verify that the cap rock has sealing competency, surface samples are gathered in certain locations and then analyzed by Rock-eval 6.

Geology: The Yortshah aquifer anticline is located in the Northwest of Salt Lake, between Qum and Tehran cities. Upper red formation which has a thickness of 79 m, is the cap rock and composed of mudstone and anhydrite. Qum formation with a thickness of 370 m is the storage zone and is composed of limestone, dolomite and marls [Fig. 1]. Yortshah gas storage reservoir is located in the Qom Basin. Tectonic activities taking place in Qom Basin has produced certain changes in Yourtshah structure which have prevented sedimentation in some members of formations of Qom Basin. Regional stratigraphic column of Yourtshah Aquifer is described below.

The Qum formation is mainly consist of marine limestone layers of upper Oligocene to lower Miocene age. The Qum formation is subdivided from base to top to 9 members, of which only four youngest members are found in the Yortshah structure that include:

C4: marl and limestone
D: gypsum and shale
E: marl and limestone
F: limestone

The c4 member transgressed directly onto the Eocene volcanic rocks and the lower red formation are not present on the Yortshah anticline.

The Qum formation is covered by the upper Red formation (URF), a thick sequence of mudstones and sandstones with local conglomerates, anhydrite layers and gypsum layers of middle to upper Miocene age. These are deltaic river fan sediments and coarser detrital sediment laid down in an arid climate. The lower M1 member of this formation, consisting of interbedded gypsum, anhydrite, siltstone and claystone, forms the seal (cap rock) of the potential Qum reservoir.

Due to the presence of tectonic forces in the Yortshah region, existing faults and joint system of the region are expanding and new ones are being created. This phenomenon has had a great impact on Yortshah aquifer anticline. For example high porosity and permeability of reservoir is a result of regional tectonic activities [Fig. 2].

Existing faults in the region include:

- North Fault
- South Fault
- Other longitudinal and transverse minor faults

These faults usually extend the fractures in the reservoir.

Collection Method: A total of 156 shallow samples were collected from depths of 1, 2 and 3 m with a portable shallow-drill system [Fig. 3]. The portable shallow-drill system was checked and tested prior to drilling in field. This method provides a means to acquire samples rapidly throughout a broad area (excellent for regional grid or matrix surveys). This portable system, requiring a minimal amount of logistics (both personnel and equipment), is employed to sample at locations inaccessible to a drilling rig.

Because in this method identifies free hydrocarbons, which have migrated to the surface and reside in the soil pore space, it is important that sample locations chosen in areas have no changes during drilling. In the Yortshah study area, we have a flat area without steep sloping ridges, bedrock was contacted within less than 8 m of surface penetration. If this condition occurred, multiple attempts were made to achieve the sampling at first location and we don't need to find another point for sampling nearby location. In this condition, we haven't any problem for location of sampling.

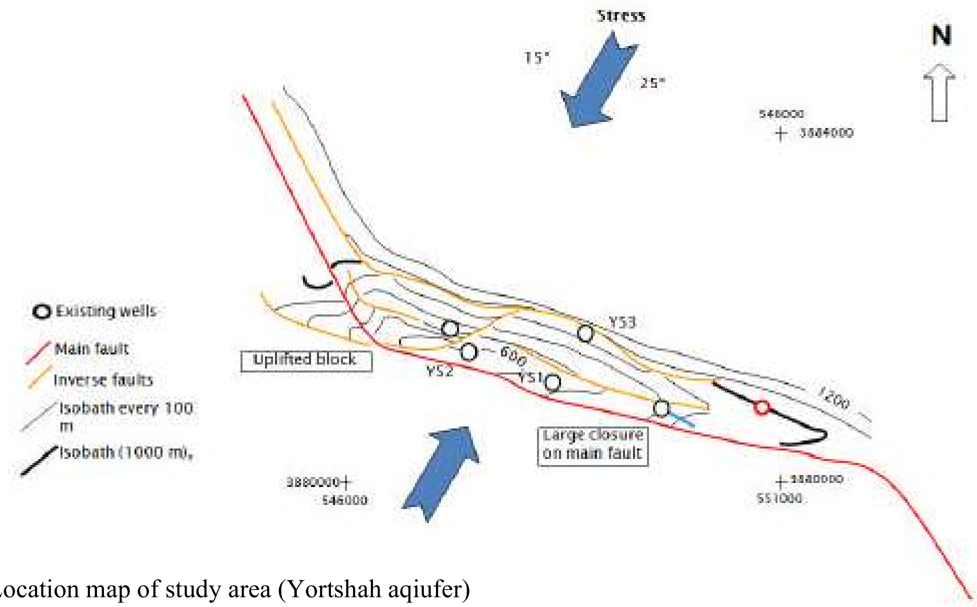

Fig. 1: Location map of study area (Yortshah aqiufer)

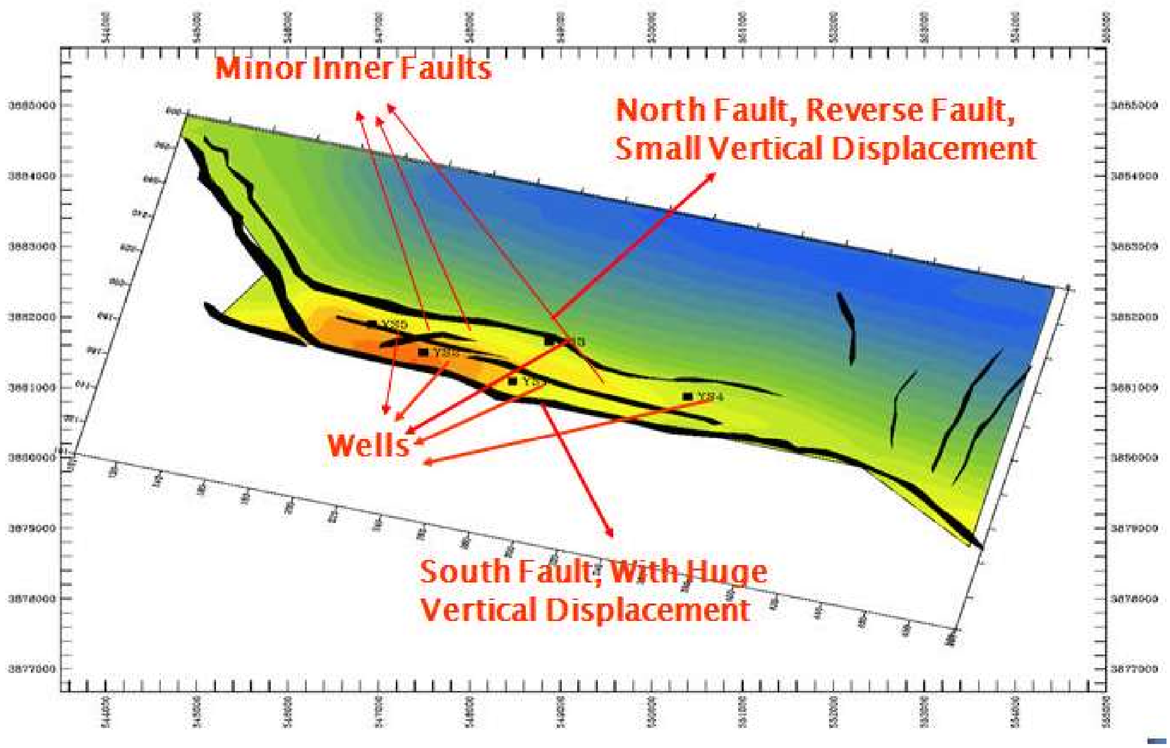

Fig. 2: Position of existing fault in Yortshah gas storage aquifer

Method of Analyses: Characterizing the organic matter from sedimentary rocks is one of the main objectives of organic geochemistry and is now widely recognized as a critical step in the evaluation of the hydrocarbon potential of a prospect. During the last two decades, various authors have used pyrolysis methods to provide data on the potential, maturity and type of the source rocks in different sedimentary basins [10]. Among these techniques, Rock-Eval pyrolysis has been widely used in the industry as a standard method to find the resource of seepage. This technique uses temperature programmed heating of a small amount of rock (100 mg) in an inert atmosphere (helium or nitrogen) so as to determine: the quantity of free hydrocarbons present in the sample

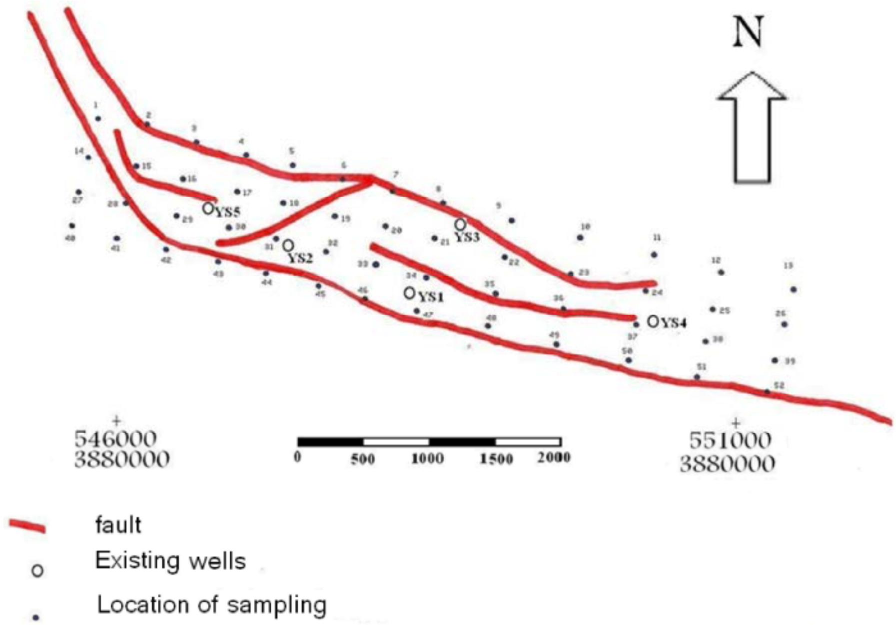

Fig. 3: Location of 52 boreholes in surface horizons of Yort-E- Shah reservoir

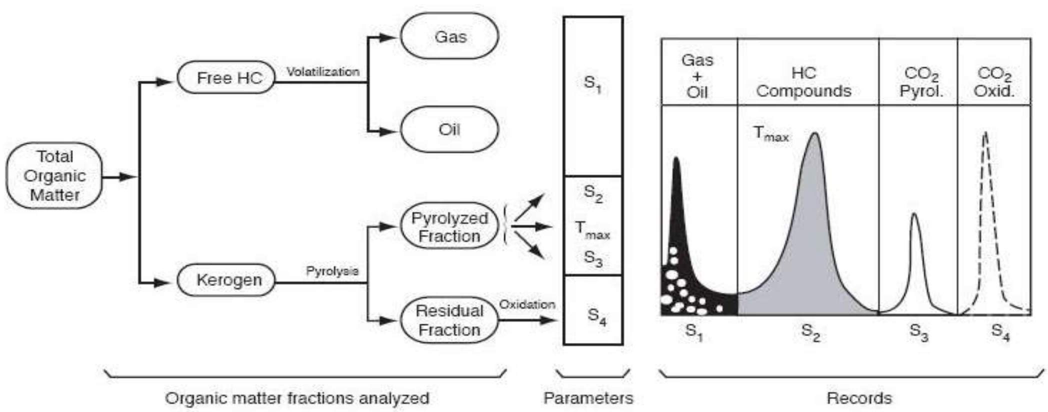

Fig. 4: General diagram showing the different fractions of the total organic matter of analyzed rocks, the corresponding parameters and their recordings.

(S_1 peak) and the amount of hydrocarbons and compounds containing oxygen (CO_2) that are produced during the thermal cracking of the insoluble organic matter (kerogen) in the rock (S_2 and S_3 peaks respectively). Furthermore, the Total Organic Carbon (TOC) content of the rock is determined by oxidation under air, in a second oven, of the residual organic carbon after pyrolysis (S_4 peak). The method has not evolved much over the years [11] [Fig. 4].

However, the new Rock-Eval 6 apparatus incorporates major changes in the methodology. As a consequence, new scientific applications of the method are proposed. As we will see in the following, some of these applications are new and therefore expand the fields of use of Rock-Eval methodology, while others are mainly improvements of the existing method. In this respect, we will first present the Rock-Eval6 functions and we will then detail their different applications (use of mineral carbon determination in carbonate sequences, application of new oxygen indices, application of high temperature Tmax (temperature measured at the top of the S_2 peak) and use of the improved total organic carbon (TOC) determination). Finally, we will illustrate more specific applications of Rock-Eval6 data in reservoir geochemistry and in soil contamination studies [12].

Analyses of all the soil samples were carried out also with the latest version of the Rock-Eval6 apparatus. The Rock-Eval6 includes a pyrolysis module, an oxidation module and an automatic sampler that we can obtain S_1 data (free hydrocarbons) of pyrolysis.

The bulk Rock-Eval data of the whole rock samples and soils were determined using standard heating conditions with Delsi Oil Show Analyzer (OSA). The pyrolysis oven was programmed as follows: hold at 300 °C for 5 min, then temperature was increased at a rate of 25 °C min^{-1} from 300 to 600 °C that obtained S_1 and S_2.

S_1 is the area of first peak which corresponds to thermovaporized-free hydrocarbon compounds present in the rock which volatilize at temperatures below 300 °C. This area gives the quantity of free hydrocarbons (oil and gas) contained in the rock, expressed in milligram hydrocarbon per gram of rock (mg HC/g rock) [13].

S_2 is the area of second peak which corresponds to the hydrocarbon compounds originating from kerogen cracking (pyrolysis of the kerogen up to 530 °C). This area (S_2), gives the residual petroleum potential of the rock, expressed in mg HC/g rock. S_2 corresponds in addition to the thermal degradation products of the involatile but extractable asphaltenes and resins [13].

In this present study, S_1 values are extremely low ranging from 0.01 to 0.73 mg HC/g rock.

Results of Rock-Eval Analysis: The amount of S_1 parameter has been calculated in mgHC/g Rock. The amount of free hydrocarbon in samples varies between 0 to 0.73.

Geological studies shows that some of the Qom formation horizons and lower formations such as Shemshak in central Iran and Alborz, have features of source rock and are capable of producing gas and some portion of produced gas and condensate are accumulated in reservoir horizons of Qom formation, like Serajeh Gas field. In the study area, a major part of free hydrocarbons of surface horizons is the result of migration from gas producing zones of Qom formation that has made their way to upper horizons. Due to the low level of organic materials in investigated samples, surface horizons gas cannot have a biogenetic origin [14]. The amount of tmax in samples shows the immaturity of organic materials in the samples, so these gases do not have an in situ origin and are mainly migrated gases from lower horizons. To better understanding the distribution of hydrocarbon compounds in upper horizons of Yortshah gas storage reservoir, the variational map of S_1 parameter was drawn by the Surfer 7 software.

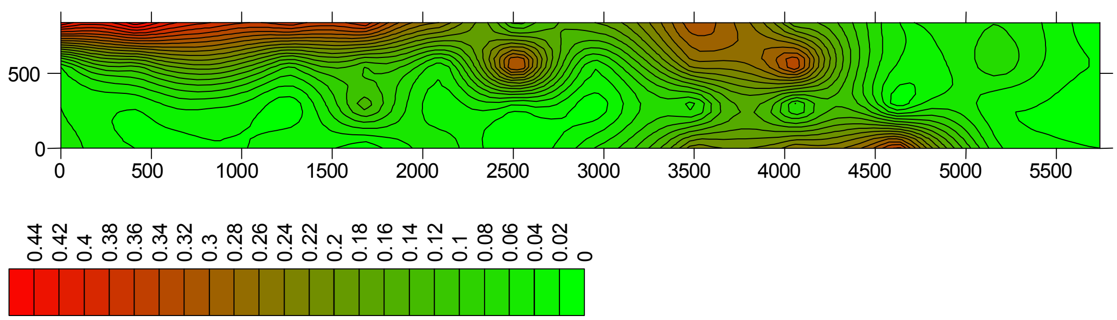

Fig. 5: Contour map variation of free hydrocarbons at 1m depth of the studied boreholes

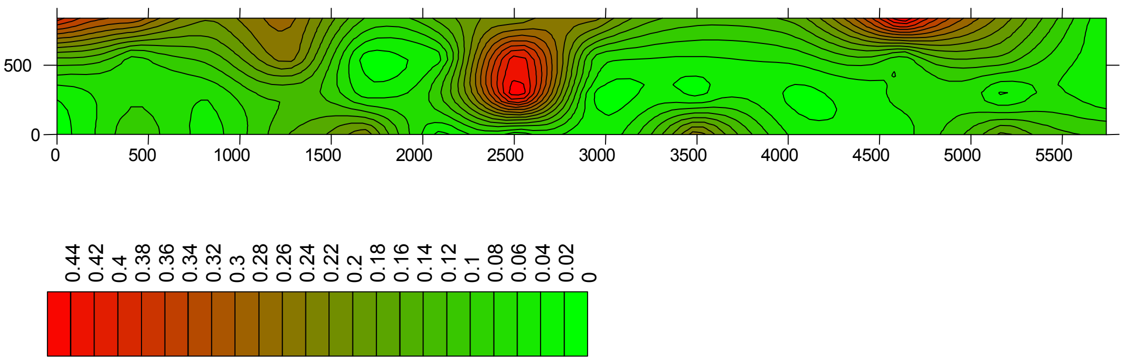

Fig. 6: Contour map variation of free hydrocarbons at 2m depth of the studied boreholes

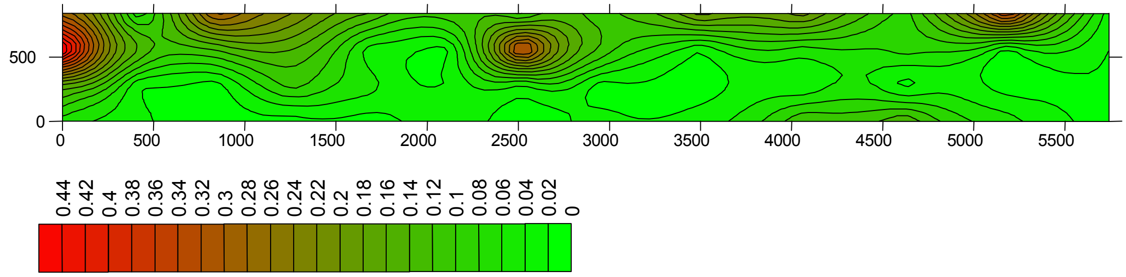

Fig. 7: Contour map variation of free hydrocarbons at 3m depth of the studied boreholes

Contour Maps of Hydrocarbon Dispersion: Distribution trend of the amounts of hydrocarbon dispersion in sampled depths is shown in the following figures [Fig. 5, Fig. 6, Fig. 7].

As shown in these maps, the amount of free hydrocarbons increases toward the north fault. Moreover there is a hydrocarbon anomaly in the area between Yortshah wells no. 1 and 3. It seems that higher hydrocarbon leakage in this area is due to higher number of fractures in this region relative to other parts of the reservoir. There is a high leakage in North West part of the field which can be a result of flow through northern Yortshah fault. Yortshah structure is a high pressure aquifer with high flow. The increase in Qom Formation thickness towards the north of the region and also, the groundwater hydraulic flow direction, which is towards North and North West of the region, can have an impact in leakage increase in northern parts.

CONCLUSIONS

The amount of free hydrocarbons that exist in the upper horizons samples of Yortshah reservoir, varies between 0-0.73 (mg/g Rock) which is insignificant. In addition, major part of these surface horizons free hydrocarbons is the result of migration from gas generating zone of Qom formation to upper horizons. Given the contour maps of free hydrocarbons changes in soil, some increasing variations are observed in the amount of S_1 toward the north of the reservoir. Furthermore, this relative increase is evident in three maps of deferent depths (1, 2 and 3m). Considering effective parameters in region, this increase in S1 amount can be thought as a result of the north fault that is one possible area for seepage in the district. Moreover, there is a hydrocarbon anomaly in middle sections which can be related to secondary faults and fractures. It seems that higher hydrocarbon leakage in the area between wells no. 1 and 3 is mainly due to higher occurrences of fractures in this region relative to other parts of the reservoir. For prevention of gas seepage via north fault, final depth of gas storage must be chosen so that the effect of north fault is omitted. Thus we can store gas in Yortshaha quifer in depth of 1000 m beneath the surface so that the probability of seepage occurrence in Yortshah gas storage aquifer will be eliminated.

REFRENCES

1. Staff Report, 2004. Current state of and issues concerning underground natural gas storage, federal energy regulatory commission, 3 sep 2004.
2. Bennion, D.B., F.B. Thomas, T. Ma and D. Imer, 2000. Detailed Protocol for the Screening and Selection of Gas Storage Reservoirs. paper prepared at the 2000 SPE/CERI Gas Technology Symposium, Alberta Canada, 3-5.
3. Hale, M. (ED.), 1995. Geochemical Remote Sensing of the Sub-Surface, Handbook of Exploration Geochemistry, Vol 7. Elsevier.
4. Victor, T.J. and *et al*. 2004. A Successful Integration of Surface Soil Gas Geochemistry with Geology and Geophysics, In Review, AAPG Search and Discovery Electronic Journal Site.
5. Baum, M.G., K.H. Blechert, M. Wanger and M. Schmitt, 1997. Application of Surface Prospecting Methods in the Duth North Sea, Petroleum Geoscience, 3: 171-181.
6. Parduhn, N.L., 1995. Geomicribiological prospecting for petroleum and mineral, *in:* R.R. Books, C.E. Dunn and G.E.M. Hall, Biological systems in mineral exploration and processing, Ellis Harwood, New York, pp: 177-206.
7. Tedesci, S.A., 2007. Surface Geochemistry In Petroleum Exploration (Hardcover). Springer; 1st edition (March 30, 2007). ISBN-13: 978-0412993015.
8. Schumacher, D., 1996. Hydrocarbon-induced alteration of soils and sediments, in D. Schumacher and M. A. Abrams, Eds., Hydrocarbon migration and its nearsurface expression: AAPG Memoir, 66: 71-89.

9. Schumacher, D., 1996. Hydrocarbon-induced alteration of soils and sediments, in D. Schumacher and M.A. Abrams, Eds., Hydrocarbon migration and its nearsurface expression: AAPG Memoir, 66: 71-89.
10. Schumacher, D. and A. Abraham, 1996. Hydrocarbon migration and its near-surface expression: AAPG Memoir, 66: 445.
11. Harbert, W., V.T. Jones, J. Izzo and T.H. Anderson, 2006, Analysis of light hydrocarbons in soil gases, Lost River region, West Virginia: Relation to stratigraphy and geological structures. The American Association of Petroleum, Geologists. AAPG Bulletin, v. 90, no. 5 (May 2006), pp: 715-734.
12. Lafargue, E., F. Marquis and D. Pillot, 1998. Rock-Eval 6 application in hydrocarbon exploration, production and soil contamination studies, Rock-Eval 6 application. Vol.53, N 4, JUILLET-AOÛT.
13. Joris, P.A., T.K. Quika, H. Veldb and A.A. Koelmansa, 2008. Quantification methods of Black Carbon: Comparison of Rock-Eval analysis with traditional methods. Aquatic Ecology and Water Quality Management Group, Department of Environmental Sciences, Wageningen University, J. Chromatography A, 1216: 613-622.
14. Schumacher, D., 2004. Soil Gas Hydrocarbones and their Exploration Significance, Geo-Microbial Technologies, Inc.