# GEOCHEMICAL METHODS OF PETROLEUM EXPLORATION

[1]Atharva Sharma
[2]Deepak Chaturvedi

[1]B.Tech-Applied Petroleum Engineering-Gas Specialization (III Year)
[2]B.Tech-Computer Science Engineering with specialization in Oil & Gas (III Year)

University of Petroleum and Energy Studies, Bidholi via Prem Nagar, Dehradun, Uttarakhand, India

[1]atharv.sharma003@gmail.com
[2]deepakchaturvedi728@gmail.com

## Abstract

Modern organic geochemistry has a firm place in petroleum industries. Its importance and usefulness for petroleum exploration is, however, still underestimated.

Using as a basis earlier research concerned mainly with the problems of petroleum generation and migration, it is now possible, with the help of geochemical analyses, to characterize and correlate crude oils and to relate them in most cases to their source.

Besides these qualitative aspects there are means of predicting the petroleum generation potential of a geological unit in quantitative terms. A prerequisite for this is sufficient knowledge of the relevant geology and the availability of some pertinent rock samples for geochemical analyses. This quantitative evaluation is based on the fact that insoluble organic matter (kerogen) in sedimentary rocks is partly transformed, under the influence of temperature, into petroleum-like components. The kerogen degradation process is experimentally known to be a first order reaction and can thus be adequately described by the Arrhenius equation.

The geochemical methods generally used are:-

**Micro gas survey**: The area under investigation is divided into profiles. The interval of the profiles is decided, depending upon the work and generally the distance of 2 kms taken. The laying of the profiles is just the same as is being done in case of seismic survey. The samples of the circulating mud were collected at 5 to 10m interval from exploratory wells. After the samples were collected they were taken to the laboratory for degassing.

**Gas Logging**: Gas Logging which is one of the geochemical methods of prospecting for hydrocarbons is a continuous method unlike other geophysical methods. Therefore, on exploratory wells where there may be a danger of blow out, application of gas logging is a boon. It records gas shows which are present in the mud in the form of micro concentrations.

**Hydro chemical surveys**: This method analyses formation water properties as it is closely involved in the primary mechanism that causes the accumulation, preservation and destruction of oil and gas fields. Water serves as a vehicle in transporting the hydrocarbons from their source bed to a trap, where they accumulate.

**Organo - Hydro chemical Survey:** Natural gases are understood to diffuse into edge waters only a few kilometers from petroleum accumulation. Aquifers overlying oil/gas pools show anomalous concentration of gaseous hydrocarbons. Dissolved organics have significantly high concentration in interstitial waters in source rocks during primary migration and in water expelled during clay mineral digenesis.

**Asphaltenes as frontier molecules in geochemical research:** Asphaltenes are emerging as frontier molecules in geochemical research as they provide

important clues about nature of source organics, maturation migration and secondary alteration effects. It is a major class of petroleum components that has no analogous counterpart in the in the biological system.

KEYWORDS: geochemical, hydrocarbon, logging, hydro chemical, asphaltenes.

## Geochemical Exploration Methods

Geochemical Exploration Methods are based on the assumption that the hydrocarbon found in an oil pool tent to migrate upwards because of their lower density, some of these hydrocarbon molecules may eventually reach the surface. In the proved oil/gas fields, the samples of surface are likely to have a comparatively high percentage of hydrocarbon content. Similarly, higher than average chloride content could be expected around the edges of an oil pool left by the water which has migrated and evaporated.

Geochemical method is still in an experimental stage and requires extremely precise analysis technique. It is interesting for an oil explorer because of its direct approach. The geochemical methods generally used are:-

a) **Micro gas survey**: These surveys are prominently carried out in Russia and adjoining countries.

**Method:** The area under investigation is divided into profiles. The interval of the profiles is decided, depending upon the work and generally the distance of 2 kms taken. The laying of the profiles is just the same as is being done in case of seismic survey. The samples of the circulating muds were collected at 5 to 10m interval from exploratory wells. After the samples were collected they were taken to the laboratory for degassing. The quantity of sample collected was half a litre. The chromatograph (fig.) was used for analyzing the different samples. The quantity of different gas is calculated with the help of the formula:

$$Q = \frac{L.K.V.1.88}{100}$$

Where L= length of the peak

K =derived value

V = volume of gas

**For conducting the micro gas survey, the following precautions are necessary:**

The water used for drilling of the holes should be as pure as possible.

- ➔ The bottles in which the samples are collected should be clean and washed with warm water
- ➔ The people conducting the analysis of gas in the laboratory should be so done that they are free from the atmospheric gases.
- ➔ Generally the collection of the gas samples should be so done that they are free from the atmospheric gases.

Micro Gas surveys can be used in conjunction with seismic survey to improve the quality of work in a big area and to delineate structures.

**The greatest utility of Gas Surveys has been proved in the following circumstances**:

- ➔ Prospecting for pools in stratigraphic and lithological traps.
- ➔ For deciding whether a previously discovered structural trap does contain oil or simply 'dry'

Various forms of gas surveys have been tried in other countries of the world. On the basis of these trials, it has been confirmed that the best and least ambiguous results are obtained in 'Deep gas survey' in which the subsoil atmosphere from depth 2.60 meters at various levels is examined for hydrocarbon content. A more effective version of the same is 'gas logging' undertaken in shallow, structural and deep exploratory wells. Gas surveys on experimental basis should be taken up in one particular area first and then extended to other regions.

**(b) Gas Core Surveys**: In some of the areas in the western world, gas core surveys were earlier done. The surveys were done by degassing the cores collected during drilling and analyzing gas. Such surveys are now being discontinued.

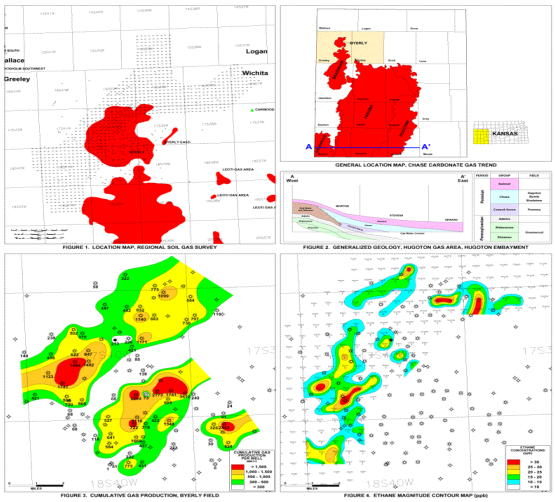

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**Fig: Soil Gas Survey**

**(c) Gas Logging**: Gas Logging which is one of the geochemical methods of prospecting for hydrocarbons is a continuous method unlike other geophysical methods. Therefore, on exploratory wells where there may be a danger of blow out, application of gas logging is a boon

Much earlier, to the penetration of productive horizons it can prewar about the approaching pool since it has got the advantage of recording the gas shows which area present in the mud in the form of micro concentrations. Much earlier, to penetration of productive horizons it can pre

warn about the approaching pool since it has got the advantage of recording the gas shows coming through diffusion process in the mud. Till such time, the mud do not heavily enriched with gas, and its parameters do not change appreciably. Therefore, gas logging is the only means on which can be relied for information of the approaching danger of a blow out.

With the latest models of gas logging units, one can have on the spot and at the very moment of drilling, an idea about the quantitative and qualitative nature of the hydrocarbon coming from the pool.

**(d) Hydro chemical surveys**: Another geo chemical method of prospecting for oil/gas is by hydro chemical surveys. As the name suggests, this method analyses formation water properties as it is closely involved in the primary mechanism that causes the accumulation, preservation and destruction of oil and gas fields. Water serves as a vehicle in transporting the hydrocarbons from their source bed to a trap, where they accumulate. Knowledge of the types, class and characteristics of water associated with oil and gas accumulations is needed in geochemical exploration.

Certain constituents dissolved in oil field water are called favorable indicators of hydrocarbon accumulations. Iodide, ammonium salt, organic acid, salts, ethane butane, low sulphate concentrations and the type and class of brine are important. Amount of aromatic hydrocarbon in formation water directly reflects the occurrence of petroleum and can be used to estimate its proximity.

Hitchon and Horn used a statistical technique discremant analysis to show that formation waters are associated with large hydrocarbon accumulations. According to them iodide and magnesium were important discriminators in water from Paleozoic age rocks with that of water from Mesozoic age rocks.

As per Suilin's classification the main subdivisions of water will be

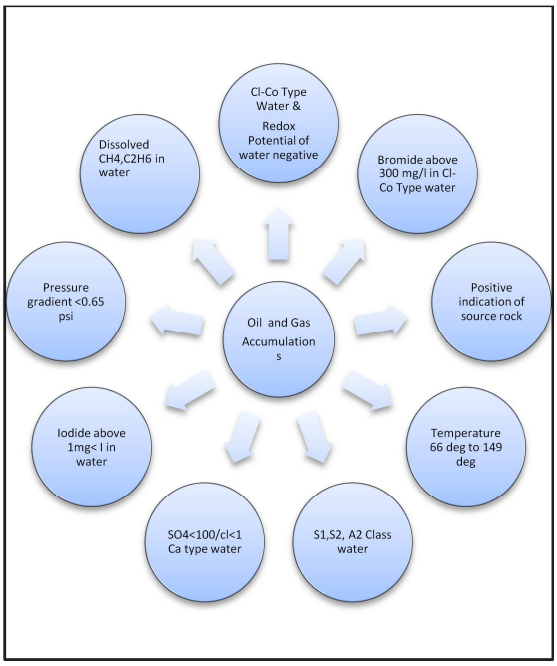
(1) Sodium sulphate type - Na2 SO4
(2) Sodium bicarbonate - Na2 HCO3
(3) Magnesium chloride - MgCl2

The oil field waters are highly concentrated in chloride, normally sulphated and saturated with calcium sulphate and carbonate. They generally contain more than 1 mg/lit of iodide and 300 mg/lit of bromide with Cl/Br ratios less than 350 and SO4 x 100 Cl ratios less than 1. Iodide and Bromide are related to bituminous substances and thus to hydro carbon accumulations.

Other important characteristics of oil field water are presence of Benzene (20 mg/lit.), the negative redox potential pressure greater than .65 psi/ft of depth and temperature greater than 66 degree Celsius but less than 149 degree Celsius.

**The figure x would show the genetic indicators related to water associated with a reservoir likely to contain oil or gas, while the other one should show the genetic indicators related to water associated with a reservoir not likely to contain accumulations of oil and gas.** Appropriate mapping of these indicators with geophysical geological information will prove useful in locating oil and gas pools.

**Fig: Oil Detection Indicators**




**(e) Organo - Hydrochemical Survey:**
Natural gases are understood to diffuse into edge waters only a few kilometers from petroleum accumulation. Aquifers overlying oil/gas pools show anomalous concentration of gaseous hydrocarbons.
Dissolved organics have significantly high concentration in interstitial waters in source rocks during primary migration and in water expelled during clay mineral digenesis. Also aerobic oxidation water washing and microbial degradation leave organo-geochemical imprints.. The most commonly employed hydro chemical indices are (i) dissolved gas (ii) total dissolved organic carbon (iii) benzene (iv) naphthenic acids & (v) aliphatic acids.

**(f) Asphaltenes as frontier molecules in geochemical research:** Asphaltenes are emerging as frontier molecules in geochemical research as they provide important clues about nature of source organics, maturation migration and secondary alteration effects. It is a major class of petroleum components that has no analogous counterpart in the in the biological system. This suggests that petroleum asphaltenes are secondary products formed after the decomposition of source material. Asphaltenes may be fragments of original kerogen from which petroleum is derived and may be expelled as a part of oil.

**(g) Sniffer Surveys:** The detection of oil and gas seeps in the offshore area by method of sniffing is now being conducted on a routine basis and is one of the most important geochemical methods being followed in the offshore areas. Hydrocarbons seeping from the sea floor dissolve in the sea water and form plumes which are transported by marine currents and mixing. These plumes can be detected at a distance of 10 km from their source area and are sometimes detectable as far as 20 km.
In order to optimize the probability of detecting seep continuous sampling must be conducted at a depth below thermocline. Analytical sensitivity must be of the order of 5 x 10-9 ml gas per ml water. In order to find out the place from where the seep is originating and to simplify data interpretation, the response time of the analytical system must be short. A computer analysis of a mathematical model has been developed to determine optimum lane spacing.
This system provides for direct detection and is specific for hydrocarbons. It would be economical if conducted abroad a vessel on conventional geophysical survey. The sniffer data has been collected and used both in the time of reconnaissance survey and during detailed exploration survey. At the time of reconnaissance, it is done with the conventional seismic equipment. The data obtained with the help of sniffer survey is utilized to confirm that the area of interest is a petroliferous area. Seeps observed are plotted on large scale map and their areal distribution and relationship to subsurface geology and structure are noted.
When this is done along with other geophysical surveys, the sniffer operator makes notes of anomalous areas which should be given special attention during the data interpretation phase. When deployed on a survey where the sniffer is considered to be particularly important the operator make certain operational decisions based on the data at the movement. The sniffer data consists both of hydrographic parameters which effect the distribution of hydrocarbon anomalies and hydrocarbon concentrations. The vessel carrying sniffer survey equipment provides a continuous measurement of the salinity and the temperature and depth sensors located in the towed body. The continuous values of

each of the Hydrocarbon components are also plotted.

**Sniffer surveys are thus a direct help in locating hydrocarbons, where the seismic surveys also indicate promising structures in the offshore areas.**

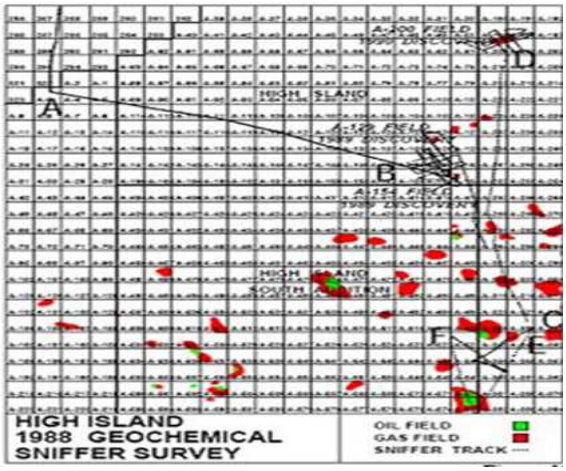



**Fig: Geochemical Sniffer Survey**



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