Petroleum Geology

Lecture(2)

Source Rocks& Kerogen types

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multiplied
porous
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maturation

A source rock It is fine clay & silt are carried together with the dead organic remains deposited under deltaic, Lacustrine & marine conditions to form organically- rich shales. It is a sedimentary rock that contains sufficient organic matter (OM), It is not less than (5%) for shale and (35%) for argillaceous limestone. so that when it is buried and heated it will produce petroleum (oil and gas). The principle biological components of living organisms are proteins, carbohydrates, lipids and lignin. The two basic requirements for the generation and preservation of organic matter in sediments are (1) high productivity and (2) oxygen deficiency of the water column and the sea bed .

Source rocks can be divided into two types

1- Sources that generated and released hydrocarbons in large quantities by forming economic (commercial) accumulations.

2- Promising source rocks (rocks source potential) that have the same ability to generate hydrocarbons, but this has not been done.

The organic matter has not yet fully matured. Kerogen constitutes 95% of the organic matter in shale rocks

Shale, Mudstone, and Marl.

The source rocks are distinguished in terms of their rocky structure by the small sizes of their grains or the crystals that compose them, i.e. they are characterized by granules.

Soft and very soft, whose sizes are smaller than 2 microns, i.e. 0.002.0 mm in diameter, reflecting the fineness of the porous system and increasing

The surface area of the grains and the high probability that they contain eternal water. In addition to containing good proportions of minerals

Clay (and within different bodies and varying in type and composition, whereby it becomes under the name of muddy rocks).

(argillaceous rocks) with different proportions of organic materials (matter organic) graded within the stage of

Thermal maturation to generate hydrocarbons.

ويمكن تقسيم الصخور المصدرية الى نوعين

1) مصدرية ولدت وحررت هايدروكاربونات بكميات كبيرة بتكوين تراكمات اقتصادية (تجارية)

2)صخور مصدرية واعدة(rocks source Potential) تملك القدرة نفسها على توليد الهايدروكاربونات

ولم يتم ذلك لعدم اكتمال نضوج المادة العضوية فيها بعد. يشكل الكيروجين (95%)من نسبة المادة العضوية في صخور السجيل (Shale)والوحل الطيني Mudstone) والصلصال(Marl).

تتميزالصخور المصدرية من حيث بنائها الصخاري بصغر حجوم حبيباتها او البلورات المؤلفة لها اي تتصف بالحبيبات الناعمة والناعمة جدا التي حجومها اصغر من 2 مايكرون اي 002.0 ملم قطرا مما يعكس دقة النظام المسامي وزيادة المساحة السطحية للحبيبات واالحتمالية الكبيرة احتوائها على الماء االزلي. اضافة على احتوائها على نسب جيدة من معادن الصلصال(clay) وضمن هيئات مختلفة ومتباينة في النوع والتركيب حيث بالتالي تصبح تحت اسم الصخور المتطينة (rocks argillaceous)مع احتوائها على نسب مختلفة من المواد العضوية(matter organic) متدرجة ضمن مرحلة النضوج الحراري لتوليد الهيدروكاربونات..

Classification of source Rock:

1 - limestone argillaceous rocks: characterized by being fine-crystalline

Medium to high compressibility, i.e. cohesive, and characterized by good proportions of insoluble materials residual Insoluble. These rocks are deposited in deep basin environments to the outer shelf. These rocks are often deposited in deep, swampy, swampy or closed bay environments. These rocks are often deposited in these two basins. The two basins are characterized by the Felsic layer.

2- Calcareous shale and loess rocks(Shaley and marly limeston RX) :These rocks are characterized by addition to being micro-crystalline with varying compressibility because it contains high proportions of insoluble waste and often More than 50% by weight of the rock, if it is characterized by stratification, it means shale calcareous rocks, and if Characterized by the characteristic of elasticity becomes Marley Limestone these rocks are deposited in deep basin environments to deep outer shelf and sometimes cosmic environments.

3- Shale rocks: These rocks are characterized by containing high levels of insoluble waste. It often exceeds 90% by weight of the rock, especially the clay minerals, which are characterized by the layering feature (Al-Falasi) contains good proportions of organic matter, which gives it different dark colors, like shale Black These rocks are deposited in deep basin environments and closed cosmic environments and under reductive condition.

تصنيف الصخور المصدرية :

1-الصخور الكلسية المتطينة: argillaceous limestone rocks تتصف بكونها دقيقة التبلور ذو انضغاطية متوسطة الى عالية اي متماسك وتتميز باحتوائها على نسب جيدة من المواد غير قابلة للاذابة residual Insolubleتترسب هذه الصخور في البيئات الحوضية العميقة الى الجرف الخارجي العميق والبيئات الالكونية او المستنقعية او الخلجانية المغلقة هذه الصخور غالبا ما تترسب في هذين الحوضيين وتمتاز بتطبق الفلسي

- 2 ◦الصخور الكلسية السجيلية والطفلية(Rx. lst marly shaly.) :تتصف هذه الصخور باالضافة الى كونها دقيقة التبلور ذو انضغاطية متباينة الحتوائها على نسب عالية من الفضالة الغير ذائبة وغالبا ما تزيد على 50 %وزنا من الصخرة اذا تميزت بخاصية التطبق معناه صخور كلسية سجيلية واذا تميزت بخاصية المرونة تصبح مارلي اليمستون تترسب هذه الصخور في البيئات الحوضية العميقة الى الجرف الخارجي العميق واحيانا البيئات الالكونية .

3-صخور السجيل(: shale) تتصف هذه الصخور باحتوائها على نسب عالية من الفضالة الغير ذائبة وغالبا ما تزيد على 90 %وزنا من الصخرة باالخص معادن الصلصال تتميز بخاصية التطبق (الفلسي) حاوية على نسب جيدة من المواد العضوية مما يكسبها الوان المختلفة الداكنة مثل السجيل االسود تترسب هذه الصخور في البيئات الحوضية العميقة والبيئات الالكونية المغلقة وبظروف اختزالية.

What we mean by Kerogen?

Kerogen is a waxy, insoluble organic substance that forms when organic shale is buried under several layers of sediment and is heated. If this kerogen is continually heated, it leads to the slow release of fossil fuels such as oil and natural gas, and also the non-fuel carbon compound graphite.[2] Shales that are especially rich in kerogen can actually be burned directly, but only have seen limited use as a fuel throughout history.[3] During petroleum generation, bitumen also forms from kerogen.[4]

There are different types or classes of kerogen. Type I consists mainly of algae and is the most likely type of kerogen to produce oil when exposed to high temperatures. Type II is a type of kerogen that is composed of a mix of terrestrial and marine organic materials and can sometimes produce oil.

Type III kerogen is composed mainly of wood-like material along with some algae and plankton, generally creating natural gas.[4]

Kerogen is considered to be a major carbon sink in the carbon cycle, containing nearly 10^{16} tonnes of carbon.[5] As well, the ability to study kerogen has led to insight in the formation of sedimentary rocks and how these organic.

Fig.(1):kerogen

Kerogen: Kerogen is an insoluble organic substance that forms when organic shale is buried under several layers of sediment and is heated.

Maturation :solid kerogen is transformed to liquid and gaseous hydrocarbons.

Kerogen Type

The kerogen types present in a source rock can be recognized on the basis of optical properties such as color, fluorescence, and reflectance.

Type-I kerogen (liptinite): Has a high hydrogen to carbon ratio (≥ 0.5) but a low oxygen to carbon ratio a low oxygen to carbon ratio (<0.1) and the potential for oil and gas is high. It is oil-prone, with a high yield (up to 80%). It is derived mainly from an algal source, rich in lipids, which is formed in lacustrine and/or lagoonal environments. Liptinite fluoresces under Ultra Violet (UV) light. Type I kerogen is relatively rare.

Kerogen Type (Cont.)

Type-II Kerogen (Exinite) has intermediate hydrogen to carbon and oxygen to carbon ratios. It is oil-and gas prone, with yields of 40-60%.

The source is mainly membranous plant debris (spores, pollen, and cuticle), and phytoplankton and bacterial microorganisms in marine sediment with medium to high sulfur content. The presence of sulfur influences the timing and rate of kerogen maturation. Exinite fluoresces under UV light. Type II kerogen are the most abundant.

Type- III kerogen (Vitrinite) has a low ratio of hydrogen (<1.0) and high ratio (>0.2 or 0.3) of oxygen relative to carbon, and therefore forms a low yield kerogen, principally generating gas.

The primary source is terrestrial higher plant debris found in coals or coaly sediments. Vitrinite

dose not fluoresce under UV light, however it is increasingly reflective at higher levels of

maturity and therefore can be used as an indicator of source rocks maturity.

Type-IV kerogen (Inertinite) is the non fluorescing product of any of above kerogens. It is high in carbon and very low in hydrogen, and is often termed “Residual kerogen” or "dead carbon” having no effective potential to yield oil and gas.

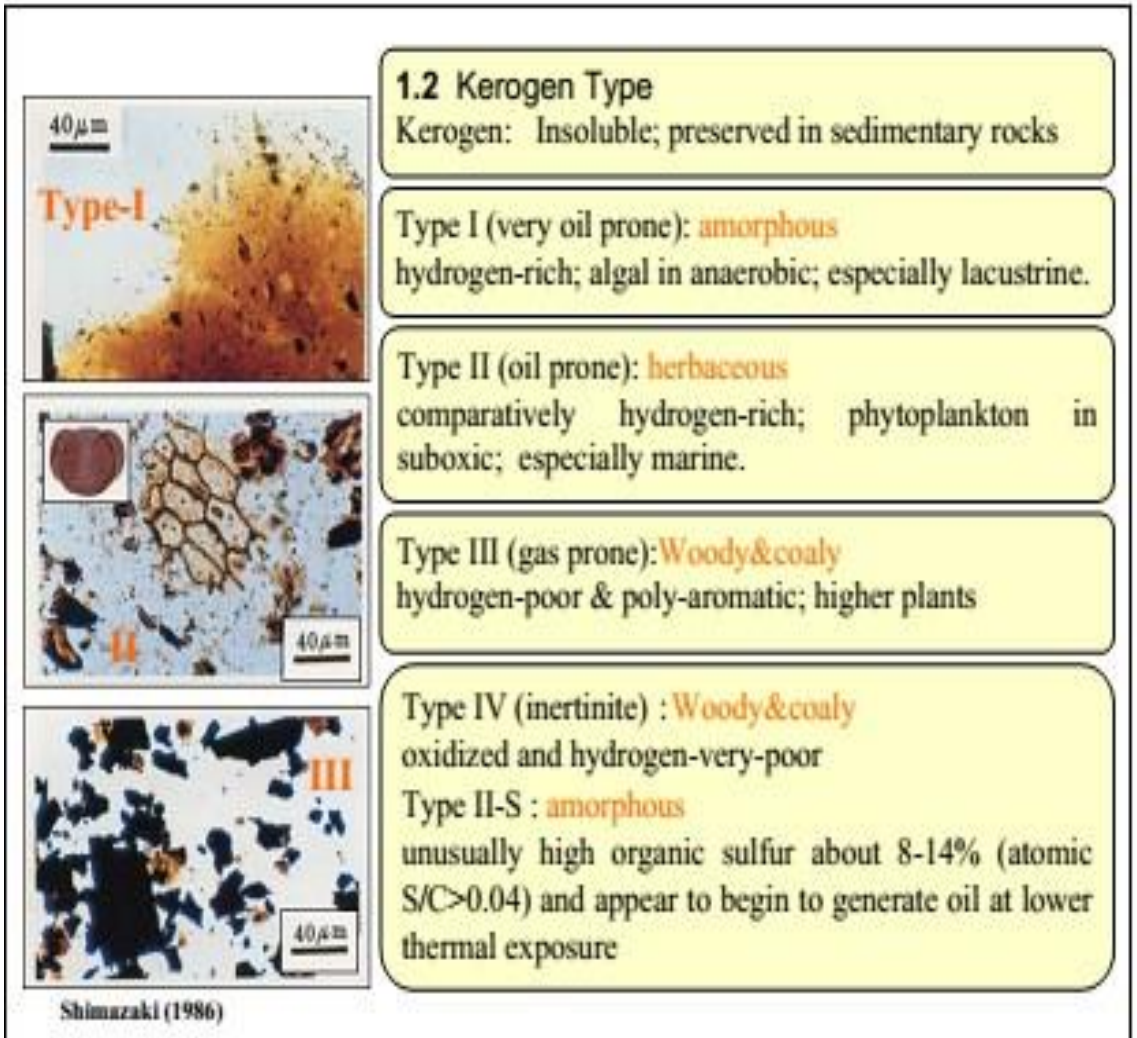

Fig.(2): Kerogen Types

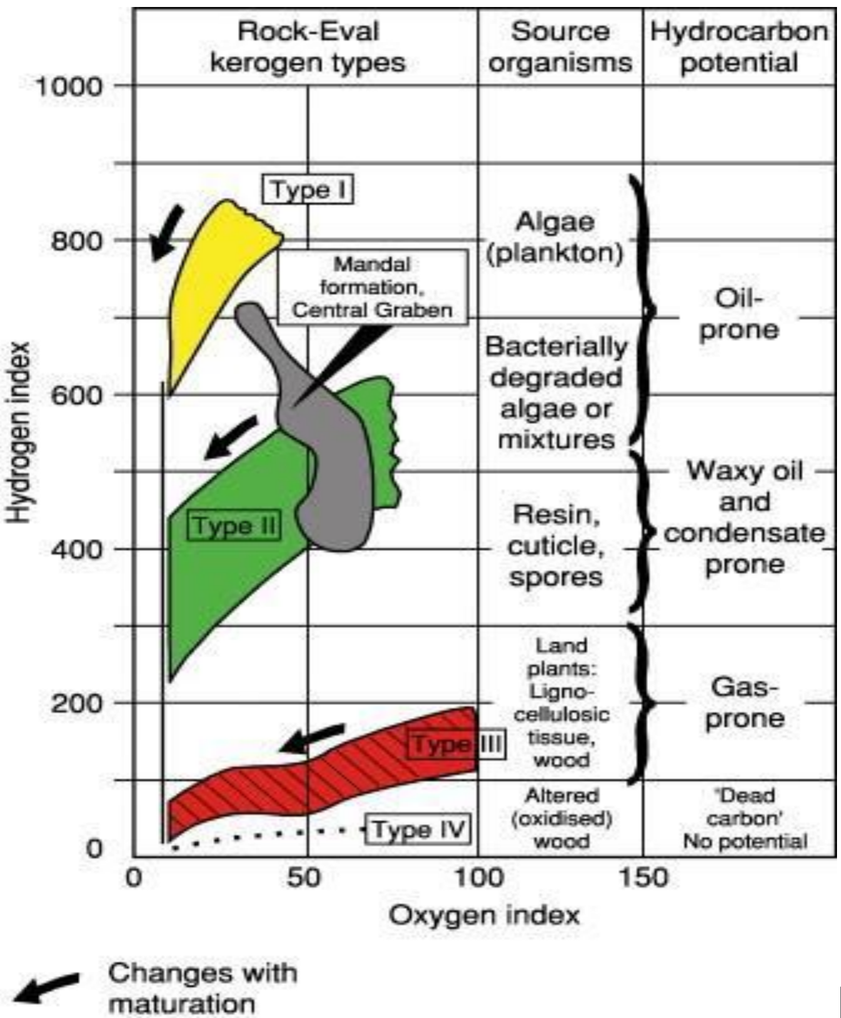

Fig.(3) composition of kerogen

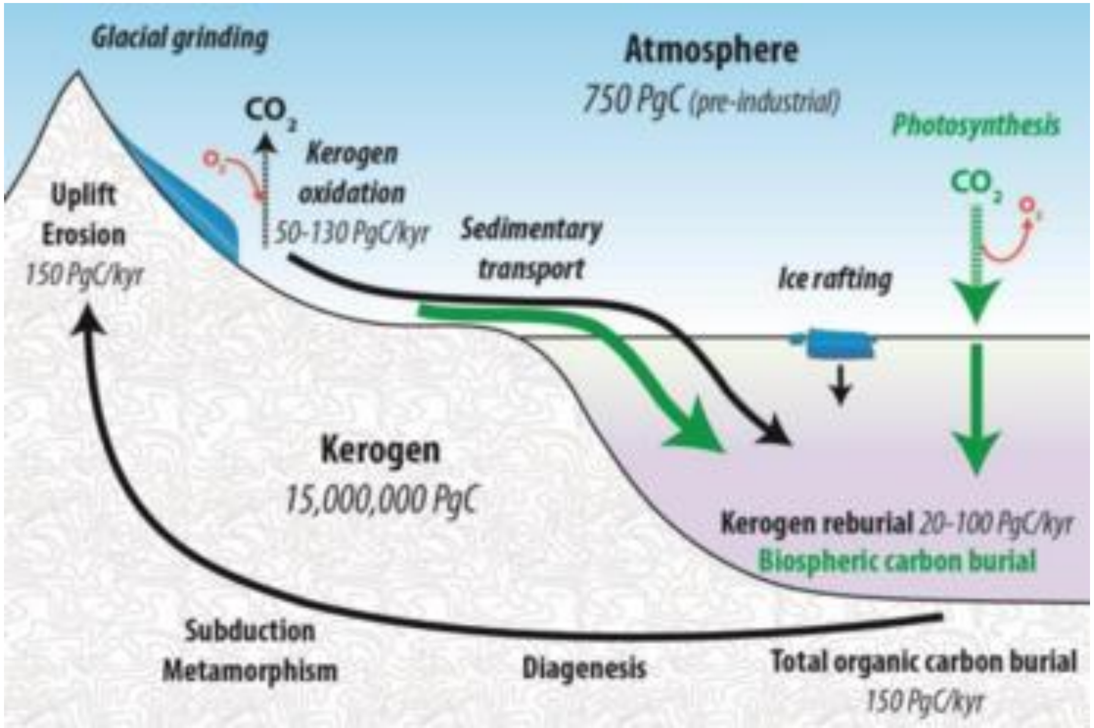

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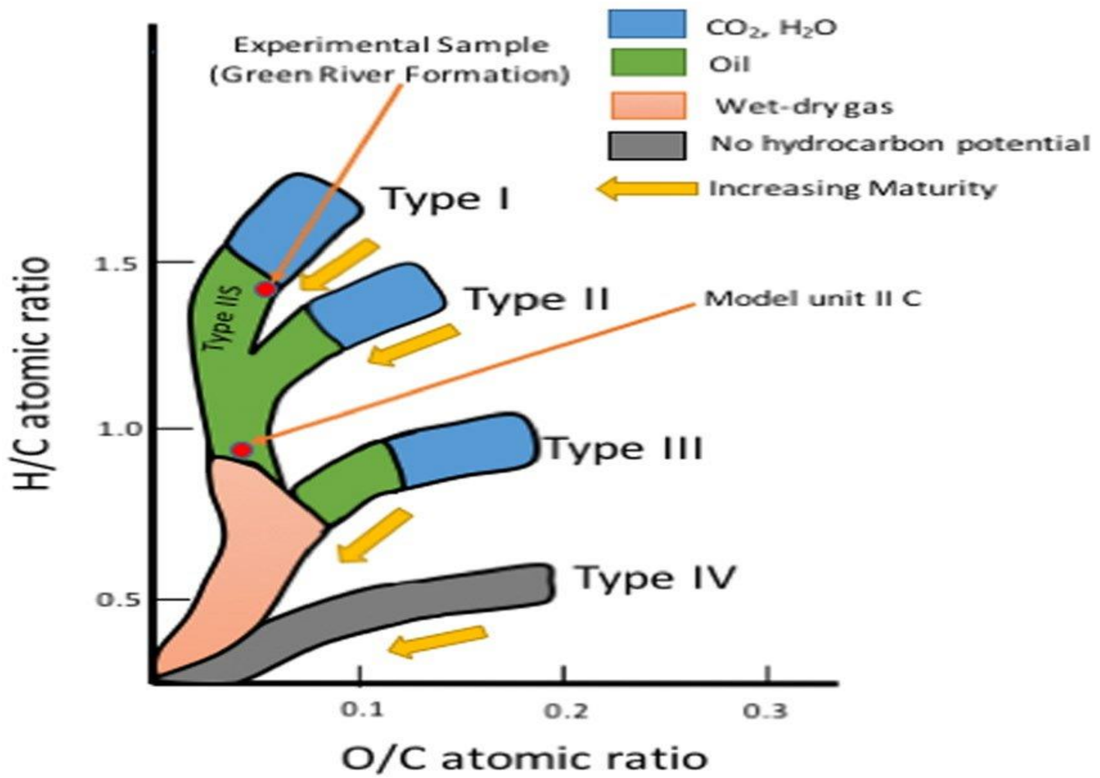
Fig.(4): Kerogen formatio



Fig(5):Krevlon diagram of Kerogen type

Formation of kerogen

The formation of kerogen represents a major step in the formation of oil and natural gas, as kerogen serves as the source of these fossil fuels. For kerogen to form, dead phytoplankon, zooplankton, algae, and bacteria must sink to the bottom of an ancient still water environment. After, this dead material must mix with inorganic, clay-like materials that enter these oceans from streams and rivers. This creates an organic-rich mud - which cannot be exposed to too much oxygen or else the organic matter within the mud is decomposed too quickly by bacteria. Before this organic matter is destroyed, it is buried by more sediment and lithifies (becomes sedimentary rock), creating organic shale.[2] If this shale is buried between 2 and 4 kilometers, its temperature increases due to its location in the Earths interior. This increasing pressure and temperature of the shale finally transforms it into kerogen.[3]

Van Krevelen diagrams are graphical plots developed by Dirk Willem van Krevelen (chemist and professor of fuel technology at the TU Delft) and used to assess the origin and maturity of kerogen and petroleum. The diagram cross-plots the hydrogen:carbon atomic ratio as a function of the oxygen:carbon atomic ratio.

Beginning around 2003, the diagrams are often used to visualize data from mass spectrometry analysis, used for mixtures other than kerogen and petroleum.[1] For example, the diagrams have been used in one analysis of the components in Scotch whiskey.[2]

Types of kerogen according to van crivlen diagram

Labile kerogen breaks down to generate principally liquid hydrocarbons (i.e., oil), *refractory* kerogen breaks down to generate principally gaseous hydrocarbons, and *inert* kerogen generates no hydrocarbons but forms graphite.

In organic petrography, the different components of kerogen can be identified by microscopic inspection and are classified as macerals. This classification was developed originally for coal (a sedimentary rock that is rich in organic matter of terrestrial origin) but is now applied to the study of other kerogen-rich sedimentary deposits.

The Van Krevelen diagram is one method of classifying kerogen by 'types', where kerogens form distinct groups when the ratios of hydrogen to carbon and oxygen to carbon are compared.[34]

Type I: Algal/Sapropelic[edit]

Type I kerogens are characterized by high initial hydrogen-to-carbon (H/C) ratios and low initial oxygen-to-carbon (O/C) ratios. This kerogen is rich in lipid-derived material and is commonly, but not always, from algal organic matter in lacustrine (freshwater) environments. On a mass basis, rocks containing type I kerogen yield the largest quantity of hydrocarbons upon pyrolysis. Hence, from the theoretical view, shales containing type I kerogen are the most promising deposits in terms of conventional oil retorting.[35]

- Hydrogen:carbon atomic ratio > 1.25
- Oxygen:carbon atomic ratio < 0.15
- Derived principally from lacustrine algae, deposited in anoxic lake sediments and rarely in marine environments
- Composed of alginite, amorphous organic matter, cyanobacteria, freshwater algae, and lesser of land plant resins
- Formed mainly from protein and lipid precursors
- Has few cyclic or aromatic structures
- Shows great tendency to readily produce liquid hydrocarbons (oil) under heating

Type II: Planktonic[edit]

Type II kerogens are characterized by intermediate initial H/C ratios and intermediate initial O/C ratios. Type II kerogen is principally derived from marine organic materials, which are deposited in reducing sedimentary environments. The sulfur content of type II kerogen is generally higher than in other kerogen types and sulfur is found in substantial amounts in the associated bitumen. Although pyrolysis of type II kerogen yields less oil than type I, the amount yielded is still sufficient for type II-bearing sedimentary deposits to be petroleum source rocks.

- Hydrogen:carbon atomic ratio < 1.25
- Oxygen:carbon atomic ratio 0.03 - 0.18
- Derived principally from marine plankton and algae
- Produces a mixture oil and gas under heating

Type II-S: Sulfurous[edit]

Similar to type II but with high sulfur content.

Type III: Humic[edit]

Type III kerogens are characterized by low initial H/C ratios and high initial O/C ratios. Type III kerogens are derived from terrestrial plant matter, specifically from precursor compounds including cellulose, lignin (a non-carbohydrate polymer formed from phenyl-propane units that binds the strings of cellulose together); terpenes and phenols. Coal is an organic-rich sedimentary rock that is composed predominantly of this kerogen type. On a mass basis, Type III kerogens generate the lowest oil yield of principal kerogen types.

- Hydrogen:carbon atomic ratio < 1
- Oxygen:carbon atomic ratio 0.03 - 0.3
- Has low hydrogen content because of abundant aromatic carbon structures

- Derived from terrestrial (land) plants
- Tends to produce gas under heating (Recent research has shown that Type III kerogens can actually produce oil under extreme conditions)[36][*citation needed*]

Type IV: Inert/Residual[edit]

Type IV kerogen comprises mostly inert organic matter in the form of polycyclic aromatic hydrocarbons. They have no potential to produce hydrocarbons.[37]

- Hydrogen:carbon atomic ratio < 0.5

Carrier Rocks

Coarse- grained and more permeable geologic layers adjacent to the source rocks.

Sand, gravel, Sandstone, Limestone, Fractured rock and basalt

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Sandsto

Bas

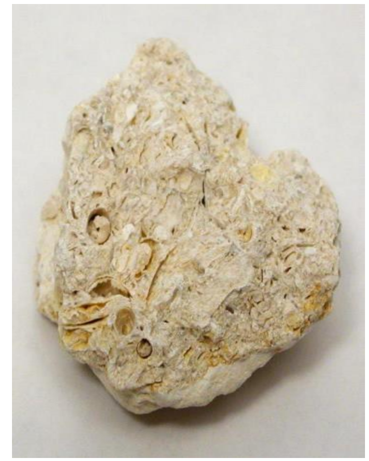

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Fig: 6-Types of rocks- carrier rocks