



Targamh
Art Of Translation

English ↔ Arabic ↔ French

GEOCHEMICAL GLOSSARY

A List of Commonly-Used Geochemical Terms

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This compilation represents the combination of several glossaries. Special thanks to Dr. Al Young, Exxon Production Research Company (retired), for getting the list started. If you note any inaccuracies or would like to contribute some terms, contact us at pra@main.com. We will update the list periodically.

ACTIVATION ENERGY - The energy which must be supplied to reacting substances to enable chemical transformation to take place; used in maturation modeling when calculating the degree of transformation of kerogen into oil and gas.

ACYCLIC - Without rings in the chemical structure; see also aliphatic.

AEROBIC - Living or active only in the presence of oxygen.

ALCOHOLS - Organic compounds containing a hydroxyl (OH) group, e.g., methyl alcohol or methanol.

ALGAE - One of the most primitive plants consisting of a single cell or a cell aggregate of low organization and without vascular system; algae live in both fresh and marine water and range from diatoms to large seaweeds.

ALIPHATIC HYDROCARBONS - Refers to hydrocarbon molecules whose carbon atoms are arranged only in chains, as distinguished from those whose carbon atoms are in rings; includes normal and branched-chain alkanes.

ALKANE - A hydrocarbon in which the valence of all the carbon atoms is satisfied by single bonds, a characteristic that chemists have termed *saturated*. Three types of alkanes are common in petroleum:

(1) *normal-alkane* (n-alkane or paraffin) - saturated hydrocarbons which have an unbranched structure.

(2) *isoalkane* (branched alkane or isoparaffin) - differs from n-alkanes in the presence of one or more points of branching within the chain.

(3) *cycloalkane* (naphthene) - Saturated hydrocarbons composed of one or more rings.

ALKENE - See [olefins](#).

ALKYL GROUP - Denotes an acyclic saturated hydrocarbon radical, general formula C_nH_{2n+1} (sometimes abbreviated in chemical structures by the symbol R-). This term is commonly used to denote an aliphatic hydrocarbon moiety which is bonded at a specific point in a chemical structure e.g., the alkyl side-chain in steranes.

AMINO ACIDS - Organic acids which, as the name suggests, possess amino (-NH₂) and carboxylic acid (-COOH) groups (e.g., CH₂NH₂COOH, glycine; CH₃CH(NH₂)COOH, alanine). These compounds are the building blocks of the proteins in living organisms; during diagenesis, their decomposition products can be incorporated into molecules which ultimately form kerogen.

AMORPHOUS KEROGEN - Kerogen which, when examined through a microscope, lacks distinct form or shape; often used to describe oil-prone material.

ANAEROBIC - Living or active in the absence of free oxygen; synonymous with anoxic.

ANOXIC - Conditions where concentration of oxygen is very low (less than 0.1 ml/liter of water).

API GRAVITY - The standard American Petroleum Institute method for specifying the density of crude petroleum. The formula used to calculate API gravity is:

$$^{\circ}\text{API} = 141.5 - (131.5 * \text{specific gravity at } 60^{\circ} \text{F})$$

- Low gravity (heavy oil) <20° API
- Medium gravity 27° API+
- High gravity (light oil) >35° API

AROMATIC HYDROCARBONS - Hydrocarbons possessing a specific type of carbon-carbon double bonding (named a *benzene ring*) as the basic structural unit. Differ from naphthenes (cyclic alkanes) in that they contain double bonds.

AROMATIC STERANES - Aromatic hydrocarbons which are probably derived from sterols. Two types are common: monoaromatic steranes (one aromatic ring) and triaromatic steranes (three aromatic rings).

ASPHALT/ASPHALTICS - Dark brown, viscous liquid or low-melting solid that contains asphaltenes and resins, is soluble in carbon disulfide and insoluble in n-heptane. Asphaltenes occur as tiny colloidal particles dispersed in the oil, and are commonly isolated in the laboratory by precipitation in pentane (see below). The higher the proportion of asphaltene, the harder the residual asphalt.

ASPHALTENES - Constitute a general class of aromatic-type substances which are defined on the basis of their solubility: Asphaltenes are soluble in carbon disulfide and insoluble in light alkanes such as n-pentane and n-heptane. Asphaltene molecules carry a core of stacked flat sheets of condensed (fused) aromatic rings linked at their edges by chains of aliphatic and/or naphthenic-aromatic ring systems. The condensed aromatic sheets contain NSO atoms and probably vanadium and nickel complexes.

BACTERIAL OXIDATION & REDUCTION - Bacteria require an energy source in order to carry on their life processes. The source is provided by exothermic chemical reactions involving oxidation and/or reduction. Geochemically, the following types of reaction are important;

Aerobic decay - conversion of organic matter into CO₂ (oxidation), e.g.,

Organic Matter + 2O₂ => CO₂ + 2H₂O + Energy

Fermentation - the anaerobic conversion of organic matter into products other than CO₂, e.g., glucose into ethyl alcohol or lactic acid.

Anaerobic decay - conversion of organic matter into H₂S and CO₂ by sulfate-reducing bacteria:

Organic Matter + SO₄ => H₂S + CO₂

BASE PEAK - Dominant fragment produced during gas chromatography/mass spectrometry (GC/MS).

BENZENE - A common liquid hydrocarbon in petroleum, formula C₆H₆: the simplest of the aromatic series.

BIODEGRADATION - This term normally refers to the alteration of petroleum by living microorganisms, primarily bacteria, which may occur when a reservoir is exhumed, when oil seepage reaches the surface or near surface, or when meteoric water is introduced into an accumulation. Oils which have been biodegraded exhibit distinct compositional changes, including:

- loss of n-alkanes

- increase in the content of asphaltenes

- increase in sulfur content and decrease in API gravity

BIOGENIC GAS - Methane which is produced by the action of bacteria on organic matter at relatively shallow depths. Compositionally, it consists almost entirely of methane (99.9%) which is isotopically light when compared to thermogenic gas.

BIOLOGICAL MARKER (BIOMARKER) - Compounds found in petroleum or rock extracts which possess a carbon skeleton that indicates an unambiguous link with a natural product. The most common biomarkers in petroleum include isoprenoids, triterpanes and steranes.

BISNORHOPANE - A 28-carbon hopane with two methyl groups removed relative to the 30-carbon hopane. This compound is frequently very abundant in sulfur-rich oils and corresponding source rocks e.g. Monterey Formation.

BITUMEN - The term is used in two distinct senses:

(a) A general name for the fraction of organic matter in sediments and rocks that is soluble in benzene, benzene-methanol, carbon tetrachloride, etc. (i.e., extractable organic matter) - a complex mixture of hydrocarbons, asphaltenes, NSO-containing compounds and other heterocyclic non-hydrocarbons.

(b) An even more general name for various solid, semisolid, and liquid hydrocarbons.

BOTRYOCOCCANES - A series of long-chain isoprenoid hydrocarbons formed from *botryococcene*, a natural product found in the algae *Botryococcus braunii*. The most abundant compound, botryococcane, contains 34 carbon atoms.

BRANCHED CHAIN - The alkanes are classified as "branched chain" when more than two carbon atoms are linked to at least one carbon atom.

BURIAL HISTORY - The burial of one or more horizons traced through time is known as burial history. The data are usually represented graphically as depth-time plots and are used in conjunction with thermal models to estimate the maturation history of source rocks.

n-BUTANE - A normal alkane with a continuous chain of 4 carbon atoms (C₄H₁₀); often in the gas phase.

C1 -C4 - Geochemical analysis of methane (C₁) through butane (C₄) gases in cuttings, waters. Synonymous with cuttings-gas.

C4 -C7 - Geochemical analysis of butane (C₄) through heptane (C₇), liquid hydrocarbons in sediments, oils, and waters. Synonymous with gasoline-range hydrocarbons.

C4 -C19 - High-resolution chromatographic analysis of butane (C4) through nonadecane (C19), liquid hydrocarbons in oils.

C15+ - Geochemical analysis for heavy liquid hydrocarbons (saturates and aromatics) and non-hydrocarbons (NSO compounds and asphaltenes).

CARBOHYDRATES - A class of natural organic compounds composed of carbon, hydrogen, and oxygen in units of five or six carbon atoms. They include sugars, starches and cellulose.

CARBON DIOXIDE - Gas, formula CO₂, which is the fundamental form in which carbon is cycled through plants, animals and carbohydrates.

CARBON NUMBER - Refers to the number of carbon atoms in a molecule.

CARBON PREFERENCE INDEX (CPI) - Generally the ratio of abundance of odd over even carbon number paraffins, specifically calculated over the C24-C34 range. Hydrocarbons derived predominantly from terrestrial sources and/or at low maturity exhibit a predominance of odd-numbered alkanes (resulting in a high CPI); this feature disappears with increasing maturation level (CPI approaches 1.0).

CAROTENOIDS - Isoprenoid hydrocarbons containing 40 carbon atoms; they are red to yellow pigments which occur in plants and algae. The most significant is b-carotane, which frequently occurs in extracts and oils derived from lacustrine organic matter.

CELLULOSE - The most common complex carbohydrate; it is the main component of the cell walls of woody part of plants; chemical formula (C₆H₁₀O₅)_x. Insoluble in water and all organic solvents. Carbohydrates are seldom preserved in sediments beyond the diagenesis stage of alteration.

CHEMICAL REACTION EQUILIBRIUM - A state of balance between two or more chemical reactions. The amount of any substance being built up is exactly counter-balanced by the amount being used up in other reactions, so that concentration of all participating substances remains constant.

CHEMICAL REACTION KINETICS - Study of the rates at which reactions occur.

CHLOROPHYLL - The green plant pigment that is involved in the process of photosynthesis; found also in marine phytoplankton and certain bacteria. Petroleum porphyrins may be derived from the four-ring pyrrole nucleus of chlorophyll.

CHOLESTANE - A 27-carbon sterane derived by reduction from the steroid alcohol cholesterol. Its abundance in source rocks and oils is often characteristic of algal inputs.

CHROMATOGRAMS - Record of detector response (intensity vs. time) during gas chromatography. Individual hydrocarbons appear as peaks above a baseline, and may be identified and quantified.

CHROMATOGRAPHY - A technique for separating components in a mixture based on their physical or chemical properties.

COAL - A concentration of fossilized organic matter which is greater than 50% of a rock by weight is called a coal. Vast majority of coals originated in plant debris that accumulated in situ as swamp peats. Metamorphic classification ranges from peat through lignites and bituminous coals to anthracites. Visual classifications usually designate two major coal types: humic (including fusinite, micrinite, vitrinite, exinite, resinite) and sapropelic (including cannel and boghead).

CONDENSATE - A product of condensation - known sometimes as distillate; contains hydrocarbons in the C₄ to C₁₀ range. Condensates occur in gas reservoirs of great depth and high pressure, are normally in vapor phase, but condense as reservoir pressure is reduced by production gas. Petroleum geochemists commonly use this term to refer to liquid hydrocarbons which are dominantly gas and light oil.

CONDENSED RINGS (AROMATIC, NAPHTHENIC) - Refers to a molecule containing more than one ring of carbon atoms in which adjacent rings are joined through two carbon atoms which are common to both. Also called fused rings.

CRACKING - A process whereby larger hydrocarbon molecules are broken down into smaller hydrocarbon molecules. Catalytic cracking is a refinery process which breaks down the molecules through the use of a catalyst which speeds up the reaction. The term is also used to refer to the thermal decomposition of petroleum in the reservoir.

CRUDE OIL - Unrefined oil, usually with gas in solution, as found in accumulations in the subsurface.

CUTICLE - Waxy layer formed on outer walls of epidermal plant cells; precursor of cutinite, a maceral derived from the remains of land plants and related tissue which are preserved in sediments.

CUTTINGS-GAS ANALYSIS- A specific geochemical analysis; cuttings from drilling operations are canned with water at the well site. In the lab the cuttings are homogenized in a blender, and any gases released are transferred to a chromatograph. Methane through butane (C₁ to C₄) are measured. Results are used to evaluate both kerogen type and maturity.

CYCLIC - Refers to those compounds having ring structure:

(1) *Homocyclic* - only carbon atoms in the ring.

(2) *Heterocyclic* - one or more of the ring atoms are elements other than carbon, e.g.

sulfur.

CYCLOALKANES (NAPHTHENES) - A saturated, closed-ring hydrocarbon series.

DEASPHALTING - Refinery or lab procedure for precipitating asphaltenes out of complex hydrocarbon mixture (e.g., a crude oil) by adding pentane, hexane, etc. The same process may occur naturally when methane and other gases move into crude oil reservoirs.

DECARBOXYLATION - Essentially refers to the loss of acid groups (-COOH); process whereby hydrocarbons might be formed from structurally-related carboxylic acids .

DEMETHYLATED HOPANES - Biologically-transformed products of hopanes found in in biodegraded oils; the methyl group at the C-10 position is removed through the action of bacteria. These compounds occur as late-stage biodegradation products, following the removal of paraffins and branched alkanes.

DIAGENESIS - Low temperature transformation of organic matter in sedimentary environments. Most diagenesis is biologically-mediated, but may also include chemical transformations. Diagenesis precedes oil generation ,but includes formation of biogenic gas.

DIASTERANES - Steranes in which the methyl groups attached at the C-10 and C-13 positions are "rearranged" and shift their position on the ring to the C-5 and C-14 positions through a cla-catalyzed reaction. These types of steranes increase in abundance with increasing thermal maturation; they are in low abundance in source rocks and oils associated with clastic-starved environments e.g., carbonates.

DIESEL - Refined petroleum distillate boiling in the approximate range of 230 to 300 degrees Centigrade. Diesel contains mainly hydrocarbons of 13 to 20 carbon atoms and is commonly used as an additive in oil-based drilling muds.

DITERPENOIDES - Common 20-carbon compounds found in higher plants; they are predominantly bi- and tricyclic and their presence in oils is an indicator of generation from organic matter enriched in higher plant material.

DRY GAS - Natural gas as it comes from the well is classified in the field as dry gas, lean gas, or wet gas, according to the amount of liquid vapors it contains. A dry gas contains less than 0.1 gallon gas liquid vapor per 1000 cubic feet, and a wet gas 0.3 or more.

Geochemically, dry gas is defined as follows:

(a) Reservoir gas: methane greater than 97% of total hydrocarbons.

(b) Cuttings gas: methane greater than 75% (sometimes 50%) of the total hydrocarbons.

DYSAEROBIC - Term used loosely to describe water conditions which are between aerobic and anaerobic; source rocks deposited under these conditions are frequently of fair to poor quality.

EARLY MATURE - The maturation stage when some oil and gas has been generated within a source rock prior to the main stage of hydrocarbon generation. Frequently equated with vitrinite reflectance between 0.5 and 0.6%.

EFFECTIVE SOURCE ROCK - A source rock which has generated oil and gas.

ERGOSTANE - A 28-carbon sterane; synonymous with methyl cholestane, C28 sterane.

ETHANE - A gaseous two-carbon alkane (C₂H₆) occurring in natural gas and in coal gas.

ETHYLCHOLESTANE - A 29-carbon sterane; synonymous with sitostane, C29 sterane.

EXPULSION - The loss of oil and gas from a source rock due to the increasing effects of temperature and pressure.

EXTRACTABLE ORGANIC MATTER (EOM) - Organic materials (bitumen) which can be extracted from sediments with organic solvents; usually only a small percent of the total organic matter.

FATTY ACIDS - Organic compounds containing the carboxyl (-COOH) group bonded to a normal-alkyl group. Probable petroleum precursors.

FLASHPOINT - The lowest temperature at which a combustible liquid will give off a flammable vapor which can be ignited and will burn momentarily.

FLUORESCENCE - Light emission by matter under influence of energy such as ultra-violet light. Fluorescence is diagnostic of oil-prone kerogens at intermediate and low maturity; petroleum also exhibits this property.

FORMATION WATER - Water naturally occurring in sedimentary strata; once thought synonymous with connate waters, now recognized that most water in permeable, continuous beds is meteoric, although the dissolved salts may have been carried over from the time of deposition.

GAMMACERANE - A 30-carbon pentacyclic triterpane which, in contrast to hopanes, is made up exclusively of six-membered rings. Its abundance in comparison with hopane, expressed in percent, is called the Gammacerane Index. A high abundance of gammacerane is frequently associated (but not exclusively) with hypersaline lacustrine depositional environments.

GAS-CAP - The portion of a reservoir occupied by free gas.

GAS CHROMATOGRAPHY (Gas-Liquid Chromatography) - A form of chromatography where the moving phase is a gas (helium, hydrogen, etc.) and the stationary phase is generally a solid coated with a liquid in a coiled tube (column) through which the gas flows. Used to analyze complex mixtures for their individual components.

GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS) - A tandem analytical instrument in which a gas chromatograph is coupled to a mass spectrometer. As compounds elute from the gas chromatographic column, they are fragmented and ionized in the mass spectrometer. Different compounds have characteristic fragmentation patterns, which are used in their identification. This is one of the main analytical tool for the characterization of biological markers.

GAS HYDRATE - Solid consisting of a combination of water and gas (primarily methane) found in deep water settings. Gas hydrates resemble ice in physical appearance and are stable only under a restricted range of temperatures and pressures. The gas can be either thermogenic or biogenic in origin.

GAS-OIL RATIO - The number of cubic feet of gas associated with each barrel of oil.

GAS SEEPS - Surface expressions of gas leakage.

GASOLINE - The fraction of petroleum boiling between 30 and 180 degrees Centigrade. Hydrocarbons in the gasoline boiling range range from C4 to C10.

GASOLINE-RANGE HYDROCARBONS - General term for the light hydrocarbons; often used synonymously with C4-C7, but could also include portions of C8-C10 range. These compounds can occur in mature source rocks.

GAS WETNESS - The quantity of hydrocarbon gases (other than methane) in a gas sample, expressed as a percentage of the whole sample. A gas is characterized as wet if it contains more than 5% ethane through butane. Wetness of the gas can be related to its origin.

GEOCHEMICAL FOSSILS - Biological markers.

GEOCHEMICAL ANOMALY - A concentration of one or more elements in rock, soil, sediment, vegetation, or water markedly different from the normal concentration in the surroundings. Specifically applied to abnormal concentrations of hydrocarbons in soils.

GEOCHEMICAL PROSPECTING - Prospecting for reservoired oil and gas by analyzing for hydrocarbons in the surface soil or sediments, but also other geochemical techniques, such as the search for concealed deposits of metallic ores by analyzing soils, surface waters, and/or organisms for abnormal concentrations of metals.

GEOCHROMATOGRAPHY - Process occurring during migration whereby clay minerals and organic matter preferentially retard the polar fractions of migrating petroleum, resulting in an initial enhancement of the saturated hydrocarbons.

GEOPOLYMER - Polymers formed in the geosphere as a result of chemical combination of small molecules and alteration of biopolymers. Geopolymers include fulvic acids, humic acids, and kerogens.

GEOHERMAL GRADIENTS - A measure of the rate of change (increase) of temperature with depth, usually expressed in °C/km or °F/100'. The gradient is approximately constant below an upper surface (50-400 feet) above which the temperature is affected by atmospheric temperature changes and by the circulation of ground water. Factors which can disturb the gradient are permafrost, lithology, and the presence of aquifers at depth. Gradients have a worldwide average of 1.4°F/100', but may vary from 0.3°F/100' (Bahamas) to 42°F/100' (Imperial Valley).

GRAVITY SEGREGATION - A process which may occur within reservoirs, whereby heavier molecules accumulate at the bottom of the reservoir while the top is accordingly enriched in light molecules; results in the prevalence of high API gravity oils overlying lower API gravity oils; process is probably due to movement of gas to top of reservoir.

HEADSPACE GAS ANALYSIS - Analysis by gas chromatography of the light hydrocarbon gases which collect in the headspace above canned cuttings. The abundance and composition of the gas can be used to indicate the presence of source rocks, and also reservoir hydrocarbons.

HEPTANES (C₇H₁₆) - Liquid hydrocarbons of the saturated alkane (paraffin) series containing seven carbon atoms. Normal heptane (nC₇) is one of the few light alkanes which occur in association with living things - it constitutes 98% of Jeffrey pine tree oil.

HEPTANE VALUE - A thermal maturity parameter based on the relative abundance of various isomeric C₆ and C₇ (gasoline range) hydrocarbons.

HERBACEOUS MATERIAL - Kerogen typing term which includes cuticle, spores and pollen.

HETEROCOMPOUNDS - Organic compounds containing elements in addition to carbon and hydrogen in their structure (also commonly referred to as NSOs).

HEXANES (C₆H₁₄) - Liquid hydrocarbons of the alkane (paraffin) series containing six carbon atoms.

HIGH-SULFUR OIL - Crude oil having total sulfur content of more than 0.5%.

HOMOHOPANES - Hopanes containing between 31 and 35 carbon atoms are commonly referred to as homohopanes or extended hopanes. They can be readily identified in GC/MS mass chromatograms (m/z 191) as a series of isomeric doublets which elute after the 30-carbon hopane.

HOMOLOG - A member of a series of organic chemical compounds of uniform chemical type. A homologous series shows a regular gradation in physical properties, whereby the molecule of each member of the series differs from the preceding one by a definite constant group of atoms.

HOPANES - Pentacyclic alkanes containing between 27 and 35 carbon atoms which dominate the triterpanes found in sediments and crude oils. Hopanes are derived from bacteria and are useful in maturation assessment, and in oil-oil and oil-source correlation. The parent compound, hopane, contains 30 carbon atoms and usually dominates distributions in geologic samples; numerous isomeric forms of hopanes are also common, including homohopanes, diahopanes, neohopanes, moretanenes, and demethylated hopanes.

HUMIC ACIDS - Polymeric, high molecular weight organic acids which can be extracted from soils and near-surface sediments with aqueous base. They are derived from the decomposition products of plant and bacterial remains during diagenesis.

HUMIC SUBSTANCES - Series of dark yellow to black polymers consisting of a heterogeneous mixture of molecules ranging in weight from 2,000 to over 300,000. They have lower carbon and higher hydrogen contents than kerogen; much kerogen may be formed from humic substances.

HUMUS - Decomposed soil organic matter; consists basically of humic substances plus non-humic substances such as lipids, amino acids, carbohydrates, phenols, quinones, etc.

HYDROCARBONS - Organic compounds composed exclusively of carbon and hydrogen atoms.

HYDROGENATION - Chemical combination of hydrogen with unsaturated compounds, reducing oxygen and sulfur content and converting chemically reactive, unstable hydrocarbons into stable hydrocarbons.

HYDROGEN INDEX - A parameter derived from Rock-Eval pyrolysis which measures the hydrogen richness of source rocks. It is defined as the ratio of the S₂ peak to total organic carbon content (S₂/TOC) and is expressed in mg hydrocarbons/g organic carbon. Elevated values are commonly associated with oil-prone kerogen; a direct relationship exists between hydrogen index and the H/C atomic ratio.

HYDROGEN-TO-CARBON ATOMIC RATIO (H/C ratio)- The ratio of hydrogen to carbon atoms - viz., wt. H/atomic wt. H to wt. C/atomic wt. C - in kerogens. Provides a measure of

carbon condensation - i.e., the number of carbon-to-carbon bonds (H/C atomic ratio = $12[H/C$ weight ratio]). Commonly plotted versus oxygen-to-carbon atomic ratios (O/C) on a Van Krevelen diagram to show kerogen type and maturity differences. A high H/C ratio (>1.5) at low maturity indicates oil prone organic matter.

HYDROUS PYROLYSIS - Pyrolysis in the presence of water, usually in a sealed vessel known as a "bomb". Hydrous pyrolysis is used to simulate the maturation of source rocks in the laboratory.

IMMATURE SEDIMENTS - Sediments which are incapable of generating significant quantities of oil and gas because they have yet to attain a sufficient degree of thermal stress; may be due to insufficient burial, insufficient time, or both - i.e., the time-temperature exposure is too low. Frequently equated with vitrinite reflectance $<0.5\%$ and TAI <2.2 , although the actual values will vary with organic matter type.

INSPISSATION - Evaporation of oil deposits. Loss of the gases and lighter fractions, leaves only the heavier oils and asphalt.

ISOHEPTANE VALUE - A thermal maturity parameter based on the abundance of several C7 (gasoline range) hydrocarbons. Normally used in a crossplot with the heptane value.

ISOMERIZATION - The term is commonly used to describe the apparent interconversion of two hydrocarbons which differ in their orientation about a single carbon atom.

ISOPRENE (UNIT) - Isoprene (2-methylbutane) is a five-carbon saturated hydrocarbon that forms the basic building block for many plant products (e.g., natural rubber, resin). It is the fundamental unit for the synthesis of many of the biological markers including isoprenoids, terpanes and steranes.

ISOPRENOIDS - A series of acyclic compounds composed of one or more "isoprene units". They are commonly derived from plant and bacterial precursors and are regarded as biological markers. Geochemically, the most important isoprenoids are the saturated hydrocarbons phytane and pristane.

ISOTOPES - Elements which have the same atomic number but differing atomic weights, and the same chemical properties (e.g., C^{12}, C^{13}, C^{14}). Relative abundance of isotopes is given by isotopic ratios expressed in parts per thousand relative to a standard - expressed as Delta (δ) values. Carbon and sulfur isotopes are useful in oil-oil and oil-source rock correlation.

KEROGEN - The insoluble organic matter preserved in sedimentary rocks. It is derived from the breakdown of plant and bacterial remains and yields hydrocarbons on natural burial or laboratory pyrolysis. Three types (identified as I, II and III) are commonly defined based on optical properties and elemental composition.

KEROGEN TYPE - The classification of kerogen according to its chemical composition or its visual properties. Based on C, H, O and S compositions, four basic types are recognized: I, II, II-S and III. Type I, II and II-S kerogen produce oil when mature, gas when post-mature; Type III kerogen produces gas when mature.

LIGHT HYDROCARBONS - Hydrocarbons which are gaseous and near gaseous at normal temperatures and pressures. They range from methane (C1) to octane (C8), including aromatic compounds, normal, iso-, and cyclic alkanes.

LIGNIN - A phenolic carbohydrate polymer which forms the matrix for the cellulose in the cell walls of many plants; a precursor to vitrinite or huminite..

LIGNITE - A low rank of coal between peat and subbituminous coal. Lignite is commonly used as a drilling mud additive.

LIPIDS - The term includes all organism-produced substances that are soluble in organic solvents such as chloroform and acetone. From the petroleum geochemist's standpoint, the most important components of the lipids group are hydrocarbons, waxes, terpenoids and pigments, but other substances such as fatty acids, esters and alcohols are included. (Note that this definition is similar to that for bitumen - lipids are, in a sense, very immature bitumens.)

LIQUID CHROMATOGRAPHY (LIQUID-SOLID CHROMATOGRAPHY) - A form of chromatography where the moving phase is a liquid and the stationary phase a solid. Used to fractionate an oil or extract into saturated hydrocarbons, aromatic hydrocarbons and heterocompounds.

LOM - Level of Organic Maturity (also Level of Organic Metamorphism), a maturity scale from 1-20 based on vitrinite reflectance.

LOW-SULFUR OIL - Crude oil having total sulfur content of less than 0.5%.

LOW TO MEDIUM GRAVITY OIL - Oil with gravities in the range 20° to 27° API; most low-gravity oils (<20° API) likely have been biodegraded or water-washed.

MASS SPECTROMETRY - An analytical method for identifying and measuring hydrocarbon compositions. Compounds introduced into a mass spectrometer at high vacuum are fragmented, ionized and ratios of mass to charge are measured. These ratios are related to the chemical structure of the parent compound.

MATURATION - The process of hydrocarbon generation from source rocks under the influence of heat; also used to refer to the increasing predominance of lighter hydrocarbons in oils with increasing thermal exposure. The term is synonymous with thermal alteration.

MATURITY - The thermal level required by a source rock to generate the hydrocarbon components normally found in petroleum.

MEDIUM TO HIGH GRAVITY OILS - 27° to 35° API gravity; these are the most common and constitute the bulk of the world's production.

METHANE (Marsh gas, CH₄) - The first member of the aliphatic hydrocarbon series, it is the simplest, lightest and most abundant hydrocarbon. Can be formed either from thermal decomposition of sedimentary organic matter or by bacteria.

METHANOGENIC BACTERIA - Anaerobic bacteria which produce methane by fermentation of organic matter are known as methanogenic bacteria.

METHYLPHENANTHRENE INDEX (MPI)- A thermal maturity parameter based on the abundance of phenanthrene and methylphenanthrene (3-ring aromatic hydrocarbons) compositions. The MPI is dependent on facies and kerogen type; it is most accurate for Type III organic matter and has been shown to yield unreliable maturation estimates for Type II kerogens.

METHYL STERANES - Steranes with an additional methyl group at either the 2-, 3- or 4-carbon position. The presence of 4-methyl steranes in source rocks and oils is attributed to a dinoflagellate contribution and is usually associated with lacustrine depositional environments.

MIGRATION - Migration is the process whereby hydrocarbons move from source rocks to reservoirs. Migration is divided into three categories: *primary migration* where oil and gas leave the source rock; *secondary migration* where oil and gas move along a conduit from source rock to reservoir (or are lost as seepage) and *tertiary migration* where oil and gas move from one trap to another or are lost.

MORETANES - Pentacyclic alkanes containing between 27 and 35 carbon atoms which are isomers of hopanes. Moretanenes are abundant at low maturity, and decrease with increasing maturation level; their abundance relative to hopane is a common maturation indicator.

MUD GAS - Hydrocarbon gas present in the drilling mud; may either escape from the rock crushed by the bit, or from the formation.

NAPHTHA - The word is usually applied to a narrow-boiling fraction of petroleum with volatility somewhere between that of gasoline and kerosene (approx. C₇-C₁₀).

NAPHTHALENE - An aromatic hydrocarbon consisting of two fused benzene rings.

NAPHTHENE - See cycloalkane.

NATURAL GAS - Gaseous petroleum; consists of the lighter paraffins, of which the most abundant is methane. The natural gas of commerce, as delivered to the pipelines, usually ranges between 900 and 1200 BTU per 1000 cubic feet and has the following general composition:

Methane (CH₄) 72.3 percent

Ethane (C₂H₆) 14.4 percent

Carbon dioxide (CO₂) 0.5 percent

Nitrogen (N₂) 12.8 percent

NICKEL/VANADIUM RATIO (Ni/V)- The ratio of nickel to vanadium in oils. The ratio is dependent on the oxidation potential and pH of the water during depositional and thus is characteristic of depositional environment: Ni/V greater than 10 is associated with alkaline lacustrine environments, 10 to 1.0 acid lacustrine environments and less than 1.0 is typical of marine environments.

NON-HYDROCARBON GASES - Primarily carbon-dioxide (CO₂), nitrogen (N₂), and hydrogen sulfide (H₂S), but also helium, argon, and hydrogen.

NON-HYDROCARBONS - As used in organic geochemistry, these are compounds of carbon and hydrogen which, in addition contain atoms of oxygen, sulfur, nitrogen, and/or other elements (synonymous with heterocompounds, NSO)

NON-THERMAL ALTERATION - Refers to changes in reservoir crude oils other than those resulting from heating; specifically the action of gas (deasphalting) and the action of waters (water washing and biodegradation).

25-NORHOPANES - See [demethylated hopanes](#).

NORMAL HYDROSTATIC PRESSURE - Hydrostatic pressure in porous strata and wells approximately equal to the weight of a column of water whose depth is the depth under consideration.

NSO - Nitrogen, Sulfur, and/or Oxygen containing compounds isolated during liquid chromatography. Examples: pyridine, sulfides, mercaptans, carboxylic acids, etc. NSO compounds commonly are regarded as having a structure of fused aromatic rings similar to asphaltenes (synonymous with heterocompounds).

ODD-EVEN PREDOMINANCE - Refers to the prevalence of n-alkane (paraffin) molecules with odd numbers of carbon atoms among high molecular-weight hydrocarbons (C₂₄-C₃₄). This attribute is common in immature sediments, but generally not in oils or in mature source rocks.

OIL-OIL CORRELATION - The technique whereby oils are grouped on the basis of a common source, although the source itself is not necessarily known. Parameters which are used in correlations include carbon isotope ratios and biomarker distributions.

OIL SHALE - Shale containing enough kerogen to yield possibly commercial oil upon heating.

OIL-SOURCE CORRELATION - The correlation of an oil to its parent rock formation or source rock.

OIL WINDOW - The maturity zone over which oils are generated from source rocks is referred to as the oil window.

OLEANANE - A 30 carbon triterpane indicative of higher plant contribution in the source organic matter. Oleanane has been linked to a flowering plant (angiosperm) source and has been found exclusively in Tertiary and Late Cretaceous oils and source rocks. It elutes immediately before hopane in GC/MS (m/z 191) mass chromatograms.

OLEFINS (ALKENES) - Aliphatic hydrocarbons with the general formula C_nH_{2n} which contain a double bond, a characteristic chemists have termed *unsaturation*. Olefins are present in living organisms but are rare in natural crude oils. They are readily produced in refinery cracking processes and are important in the petrochemical industry.

OPTICAL ACTIVITY - The property of certain compounds to rotate the plane of plane-polarized light. In petroleum, molecules having asymmetric carbons, in particular, biological markers, exhibit this property.

ORGANIC ACID - Compound containing the carboxyl ($-COOH$) group; usually equated with fatty acid although definition includes other types such as naphthenic, aromatic, ketonic, etc. See also carboxylic acid.

ORGANIC CARBON - In sediments and rocks, the amount of carbon in compounds derived from living organisms; distinguished from *inorganic* carbon which may be in the form of carbonates, graphite, carbides, etc.

ORGANIC FACIES - A distinctive assemblage of kerogen components which can be identified visually or has a characteristic chemical composition. Organic facies can be predicted from depositional models and is of importance in mapping the distribution of, and compositional variation in source rocks.

OXIDIZING CONDITIONS - Conditions under which free oxygen is present, thus favoring the destruction of organic matter by oxidation and lack of preservation in sediments.

OXYGEN INDEX - A parameter derived from Rock-Eval pyrolysis which measures the oxygen richness of source rocks. It is defined as the ratio of the S3 peak to total organic

carbon content (S₃/TOC) and is expressed in mg CO₂/g organic carbon. Together with the hydrogen index, the oxygen index can be used to assess kerogen type and level of maturation. There is a direct relationship between oxygen index and O/C ratio.

OXYGEN-TO-CARBON RATIO (O/C) - The atomic ratio of oxygen to carbon determined by elemental analysis of kerogens. The O/C ratios is commonly plotted versus hydrogen-to-carbon atomic ratios (O/C) on a Van Krevelen diagram to show kerogen type and maturity differences. A high O/C ratio (>0.5) at low maturity, coupled with low H/C ratio indicates oxidized organic matter with little liquid hydrocarbon potential.

PARAFFIN - See alkane (normal).

PARAFFIN-BASE CRUDE - Also wax-base; rich in paraffinic hydrocarbons of both high and low molecular weight, hence is *paraffinic* rather than asphaltic.

PEAK MATURE - The level of maturity associated with the maximum rate of hydrocarbon generation from kerogen.

n-PENTANE (C₅H₁₂) - A normal alkane hydrocarbon (paraffin) with a continuous chain five carbon atoms long.

PETROLEUM - "...that naturally occurring mixture of dominantly hydrocarbon substances - liquid, gas, or solid - which constitutes the commercial crude oil, natural gas and natural asphalt of the petroleum industry." (Hedberg, 1964).

pH - Measure of alkalinity or acidity of a solution; the log of the reciprocal of the hydrogen ion activity i.e., water with a hydrogen ion activity of 10⁻⁷, has a pH = 7. Acidity, pH <7. Alkalinity, pH >7.

PHENANTHRENE - Aromatic hydrocarbon consisting of three fused benzene rings; an isomer of anthracene.

PHENOLS (Hydroxybenzenes) - One of the oxygen containing aromatic compounds found in coal tar and in crude oil. They are closely related to alcohols; the aromatic nucleus exerts a strong modifying effect on the properties of the hydroxyl group, causing phenols to be acidic.

PHOTIC ZONE - A depth range within which photosynthesis occurs in marine and lake waters. The photic zone is limited by light penetration/turbidity and is seldom greater than 200 m.

PHYTANE - A common isoprenoid hydrocarbon containing 20 carbon atoms. Phytane is not found in living organisms but is usually present in sediments and crude oils.

PHYTOPLANKTON - Unicellular photosynthetic organisms that live in marine or lake waters. They include algae, diatoms and dinoflagellates.

POLYMER - A compound made up of one repeating structural unit (called a monomer), i.e., the combination of two or more monomers makes a polymer (e.g., natural rubber is an isoprene polymer, polyethylene is an ethylene polymer).

PORPHYRINS - Pigments that occur in small quantities in animals and plants; in nature, usually derived from the green coloring matter of plants (chlorophyll). Porphyrins are made up of four pyrrole rings linked together in an essentially aromatic structure. They occur in crude oils and sediments (petroporphyrins), esp. in the asphaltene fraction.

POTENTIAL SOURCE ROCK - A source rock which has not yet generated significant amounts of hydrocarbons due to immaturity.

POUR POINT - Temperature below which an oil becomes semisolid and will no longer flow freely; an increase in paraffin content will raise the pour point. Note: Pour point and viscosity are not necessarily related, i.e., an oil with a high viscosity need not have a high pour point.

PRIMARY MIGRATION - Migration of organic materials from fine-grained sediments (source rocks), to coarse-grained sediments (reservoir rocks); *secondary migration* occurs within the coarse-grained rocks.

PRISTANE - A common isoprenoid hydrocarbon containing 19 carbon atoms. In contrast to phytane, pristane is found both in living organisms and in sediments and crude oils.

PRISTANE/PHYTANE RATIO - The ratio of the relative abundance of the isoprenoids pristane and phytane. The ratio is characteristic of organic facies and depositional environment; values less than 1.0 are often associated with carbonate source rocks and oils while values greater than 4.0 are typical of terrigenous organic matter.

PRODUCTION INDEX - A parameter derived from Rock-Eval pyrolysis, the production index is defined as the ratio of S1 divided by the sum of S1 and S2 ($S1 / (S1 + S2)$). This parameter can be used as both a maturation indicator and also to assess the presence of in-migrated hydrocarbons (staining). Immature samples have a ratio less than 0.10; mature samples 0.10 to 0.40. Elevated values in immature source rocks are sometimes associated with staining.

PYROBITUMEN - A dark-colored, solid, infusible natural-hydrocarbon complex often associated with a mineral matrix; insoluble in water and relatively insoluble in organic solvents; with a hydrogen-to-carbon atomic ratio of less than 0.53. One of the graphitic bitumens (see reservoir bitumen).

PYROLYSIS (Destructive distillation) - The decomposition of coal, wood, petroleum or other organic matter by heating in the absence of air.

PYROLYSIS/GAS CHROMATOGRAPHY - An analytical technique which allows the products of pyrolysis to be characterized using gas chromatography. This technique provides information on the organic facies of source rocks and the likely hydrocarbon products generated on maturation.

Ro - Common abbreviation for vitrinite reflectance under oil immersion.

REARRANGED STERANES - See diasteranes.

REDUCING CONDITIONS - Conditions under which free oxygen is unlikely and thus the preservation of organic matter is favored.

RESERVOIR BITUMEN - Black, solid asphaltic particles or coatings in oil and gas reservoirs. By-products of the alteration (degradation) of pooled hydrocarbons. Divided into two subtypes according to the degradation process:

(1) Graphitic bitumen (e.g., pyrobitumen) from thermal cracking or gas-deasphalting.

(2) Asphaltic bitumen (e.g., natural asphalt) from inspissation, water-washing, or oxidation.

RESERVOIR GAS - Gas within reservoirs, may or may not be associated with oils.

RETROGRADE CONDENSATES - When the pressure in a gas condensate accumulation is reduced by production, condensation may occur in the reservoir or in the well bore. This is known as retrograde condensation.

ROCK-EVAL - A pyrolysis technique which enables the chemical composition of a source rock, and hence its hydrocarbon potential, to be determined. It involves two heating steps, the first to volatilize hydrocarbons in the source rock (S1), the second to pyrolyze the kerogen and convert the material to free hydrocarbons (S2). A third pyrolysis step generates trapped CO₂ (S3). Maturation and source quality parameters are derived from the yields associated with each step.

S1, S2, S3 - Rock Eval pyrolysis parameters derived from the peak areas associated with the various pyrolysis steps.

SAPROPEL - The word sapropel is derived from the Greek word sapos meaning "rotten". Sapropel is an unconsolidated, jelly-like ooze or sludge composed of plant remains, most often algae, macerating and putrefying in an anaerobic environment. It has an amorphous and "fluffy" look, and is produced from organic matter through the action of bacterial and possibly fungal attack. It also may be produced from precipitated humic acids.

SATURATED HYDROCARBONS - A saturated hydrocarbon is one in which the valences of all the carbon atoms is satisfied by single bonds.

SATURATE FRACTION - The fraction of crude oils and sediment extracts which contain normal, branched and cyclic alkanes, isolated during liquid chromatography.

SECONDARY MIGRATION - The migration of hydrocarbons from the source rock through permeable carrier beds, along faults and unconformity surfaces to a trap.

SOLID BITUMEN - See pyrobitumen.

SOLUTION GOR - The amount of gas that is dissolved in an oil at a given temperature and pressure.

SOURCE POTENTIAL - The ability of a source rock to yield oil or gas to a reservoir rock.

SOURCE ROCKS - Fine-grained rocks (shales or carbonates) which can yield gaseous or liquid hydrocarbons to a reservoir rock.

SOUR GAS - Gas enriched in hydrogen sulfide.

SOXHLET EXTRACTION - The most common method for removing the soluble organic matter from rocks. Solvent is heated and condensed into a chamber containing the crushed rock sample; an overflow system returns the extract and solvent back to the solvent reservoir.

STABLE CARBON ISOTOPES - Carbon has two stable isotopes, ^{12}C and ^{13}C . The measure of the relative abundance of these two isotopes is known as the stable carbon isotope ratio. Stable carbon isotopes are useful for maturation assessment (gases) and also for correlation of oils and source rocks.

STERANES - A group of cycloalkane hydrocarbons with the four-ring carbon skeleton of steroids.

STEROLS - Sterols are a class of C27 to C30 four-ring alcohols of which commonly occurring members are C27 cholesterol, C28 ergosterol, and C29 β -sitosterol. Sterols are biosynthesized by algae, dinoflagellates and higher plants. These compounds are the precursors of steranes found in petroleum and petroleum source rocks.

SURFACE GEOCHEMISTRY - The detection of hydrocarbon accumulations at depth using surface manifestations, such as seeps of oil and gas.

SWEET GAS - Gas containing primarily hydrocarbons and little or no hydrogen sulfide.

TAR, TAR MATS, TAR SANDS - The terms tar and pitch are commonly applied in the petroleum industry to any of the black, sticky, liquid or solid residues produced in petroleum refining. In geochemical parlance the word "bitumen" could be substituted for "tar" when referring to tar mats and tar sands.

TERPENE - Name given to two isoprene units joined head to tail to form a cyclic compound.

TERPENOIDS - A large class of naturally occurring, usually unsaturated, cyclic (or acyclic) compounds comprised of multiple isoprene units with attached oxygenated functions. Precursors for important classes of hydrocarbons such as isoprenoids, steroids, hopanoids and carotenoids. Terpenoids occur naturally in essential oils from plants, in tree resins, wood fat, fish-liver oils, plant pigments, tobacco, rubber, etc.

TERRIGENOUS ORGANIC MATTER - Organic detritus derived from terrestrial plants and other land organisms; distinguished from marine organic matter.

TERTIARY MIGRATION - The name given to the migration of oil and gas from an existing site of accumulation. Also referred to as phase separation-migration.

THERMAL ALTERATION INDEX (TAI) - A color index ranked from 1 to 5, and ranging from greenish yellow through amber to brown to black, which describes the degree of maturation experienced by organic matter not extractable from sediments by normal organic solvents. Spores, pollen, and leaf cuticle are the most reliable indicators for TAI.

THERMOGENIC GAS - Hydrocarbon gases which are generated from organic matter by thermal breakdown, usually at depth. They are derived from mature, gas prone kerogens or post mature oil prone kerogen.

T_m, T_s - Two 27 carbon hopanes which change in their relative abundance with increasing maturation; the T_s/T_m ratio is a common maturation indicator.

TOLUENE (METHYL BENZENE) - Aromatic hydrocarbon consisting of a benzene ring with a methyl group.

TOTAL ORGANIC MATTER (TOM) - All of the organic matter in a sample. As organic carbon can be determined directly while TOM values must be derived using factors which "assume" certain amounts of oxygen, nitrogen and sulfur, the use of organic carbon values is preferred in geochemistry. A factor of 1.22 is commonly used to derive TOM from organic carbon, but this is, at best, an approximation.

T_{max} - The temperature, in oC at which the pyrolysis yield of the S₂ peak in Rock Eval pyrolysis of a source rock sample reaches a maximum. T_{max} is used as a maturation parameter, but is kerogen type dependent. For Type II kerogens, significant hydrocarbon

generation occurs between 435 and 460 oC, however, there is little variation in Tmax during hydrocarbon generation of Type I kerogens.

TOTAL ORGANIC CARBON (TOC) - A measure of the organic carbon content in a rock, expressed as weight percent; used as a fundamental parameter for classifying source rocks in conjunction with kerogen type and maturation. Most hydrocarbon source rocks contain greater than 1.0% TOC.

TRANSFORMATION RATIO - A ratio related to the production index; it is defined as the difference between the original hydrocarbon potential of a sample prior to maturation and the measured hydrocarbon potential divided by the original hydrocarbon potential. Values range from 0 to 1.0.

TRICYCLIC TERPANES - Three ring biological marker compounds containing between 19 and 45 carbon atoms; they are common in both marine and non-marine samples. The relative abundance of tricyclic terpanes increases with increasing maturation level. These compounds are detected using GC/MS by monitoring the diagnostic ion of m/z 191.

TRITERPANES - Pentacyclic biological marker hydrocarbons containing between 27 and 35 carbon atoms. Several compound classes are included within the triterpanes, including the hopanes, oleanane, gammacerane, lupanes and ursanes. These compounds are detected using GC/MS by monitoring the diagnostic ion of m/z 191.

UCM - Abbreviation for "Unresolved Complex Mixture", it refers to the part of the saturate or aromatic hydrocarbon fraction of extractable organic matter which is not resolved into peaks during gas chromatography. Also informally known as the hump, it becomes accentuated in biodegraded oils.

UPWELLING - The vertical movement of subsurface water to the surface caused by wind-driven surface waters moving away from the continents.

VAN KREVELEN DIAGRAM - The diagram used to display O/C vs. H/C ratios in elemental analysis of organic matter. Rock Eval hydrogen and oxygen indices are displayed on a similar plot which is termed a modified Van Krevelen diagram.

VAPOR PRESSURE - The pressure at which a liquid and its vapor are in equilibrium at a given temperature. The more volatile the liquid the higher will be its vapor pressure.

VISCOSITY OF OIL - The ability to flow. Measured in arbitrary units by the time required for a specified volume of oil to flow through a hole (Saybolt seconds) or a capillary tube (centipoises) of definite size under controlled temperature conditions.

VISUAL ORGANIC MATTER - Dispersed organic matter visible with binocular microscope after digestion with HF and HCl (to dissolve mineral matter), flotation, and centrifugation. Includes primary material such as cuticle (herbaceous, woody), spores, pollen,

microplankton, algae, fungi, plant resins; and secondary products such as sapropel, mineral charcoal, polymers, pyrobitumen, and oil globules.

VITRINITE - The dominant organic constituent of coal. Vitrinite forms the familiar brilliant, black sands of coal. It results from the biochemical decomposition and coalification of plant debris.

VITRINITE REFLECTANCE - Widely used maturity indicator. It is a direct microscopic measurement made both on the vitrinite maceral of coals and on kerogen extracted from rock samples.

WATER-WASHING - A non-thermal alteration process affecting oils in reservoirs; waters flowing through the reservoir carry away the more soluble hydrocarbons (chiefly the aromatics benzene and toluene, and the light paraffinic hydrocarbons).

WAX - Commonly refers to the solid n-alkane (paraffin) hydrocarbon fraction recovered from petroleum. The term wax is commonly used to refer to n-alkanes in petroleum containing greater than 25 carbon atoms; hence an oil enriched in these components would be termed "waxy" (not to be confused with the term *paraffinic*, which refers to an abundance of n-alkanes in petroleum without any implied carbon number preference).

WET GAS - A mixture of methane with significant amounts of ethane, butane, and propane; derived from mature source rocks.