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Al-Amri's Encyclopedia of Earth Sciences

27

موسوعة العمري في علوم الأرض

358 Q & A سؤال جواب

In

Natural Resources

الثـــــروات الطبيعيـــــة

Abdullah M. Al-Amri

Dept. of Geology & Geophysics - King Saud Univ.

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Department of Geology & Geophysics, King Saud University
P.O. Box 2455, Riyadh 11451, Saudi Arabia
Electronic issuance through the website:
www.alamrigeo.com
For inquiries and Comments, contact :
Mobile : +966 505481215 , Tel. +966 114676198
E-mail :alamri.geo@gmail.com

﴿ وَفِي ٱلْأَرْضِ ءَايَٰتٌ لِّلْمُوقِنِينَ ﴾

[سورة الذاريات : آية 20]

﴿And on the Earth are Signs for
Those Whose Faith is Certain﴾


موسوعة العلوم الأساسية

Preface

Praise and thanks to Allah who helped me accomplish this modest effort associated with writing the Scientific Encyclopedia. The comprehensive scientific encyclopedia in earth, environment and energy sciences aims to provide and serve researchers, school and university students and groups of society, due to the suffering of those interested in the problems of the scarcity of Arab references in this field. The encyclopedia is one of the largest in the world includes 30 scientific and cultural books documented and supported by pictures and simplified illustrations in approximately 6000 pages, covering five main parts:

The First Part consists of six books that discuss the age of the Earth, its shape, movements, internal structure, minerals and mining ores, gravity and its relationship to tides:

- Estimating Age of the Earth
- Earth's Shape & Movements
- Earth's Gravity & its Applications
- The Internal Structure of the Earth
- Minerals & Mining
- Tides

As for the Second Part of the encyclopedia, it included six books that link the Earth's relationship with the solar system, especially the moon, and the atmosphere, water, and vitality surrounding the Earth. As well as the role of earthquakes, explosions, volcanoes and tsunamis in affecting the structure of the earth and how to reduce its risks:

- Tsunami Waves
- Earthquakes & Explosions
- Seismic Hazard Assessment
- Volcanoes & Ways to Confront Them
- Geology of the Moon
- Spheres Surrounding the Earth

The Third Part consists of six books related to everything related to environmental problems and disasters and their solutions, climatic changes, the importance of afforestation and the treatment of global warming:

- Environmental Problems & Their Solutions
- Afforestation: Challenges & Solutions
- Climate Change & Global Warming
- Slips, Landslides & Floods
- Desertification & Drought
- Torrents & Water Dams

The Fourth Part of the encyclopedia consists of six books that discuss the relationship of Earth sciences with other sciences nuclear, and medically, as well as the role of clean, sustainable energy, economically and environmentally:

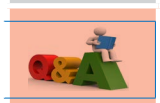
- Geothermal Energy
- Is the Age of Oil Over?
- Nuclear Geophysics
- Medical Geology
- The Future of Energy in our World
- Guide to Writing Theses & Scientific Publication

As for the Fifth Part, it consists of six books that contain 2020 Questions and Answers (Q & A) to help university students and researchers and prepare them for comprehensive and qualifying exams for postgraduate studies and practice the profession.


321 Questions & Answers in the Evolution of the Earth


358 Questions & Answers in Petrology, Geochemistry, Remote Sensing and GIS


358 Questions & Answers on Natural Resources


380 Questions & Answers in Geological Hazards


303 Questions & Answers in Seismology and Engineering Seismology


300 Questions & Answers in Applied Geophysics

Petroleum Systems

Introduction

Petroleum system is the study of oil and gas formation and exploration with its associated processes such as oil origin, occurrence, migration and their accumulation, which unifies interdependent processes and key elements in the formation of hydrocarbons. Studying petroleum system helps knowing and understanding the nature of the trap and petroleum region by basing on paleontology, stratigraphy and sedimentology of a geographic region in order to identify petroleum system. A region is said to have a petroleum system if and only if there are a presence of oil or gas seep and oozes on area or in water, with the regardless of having big quantity.

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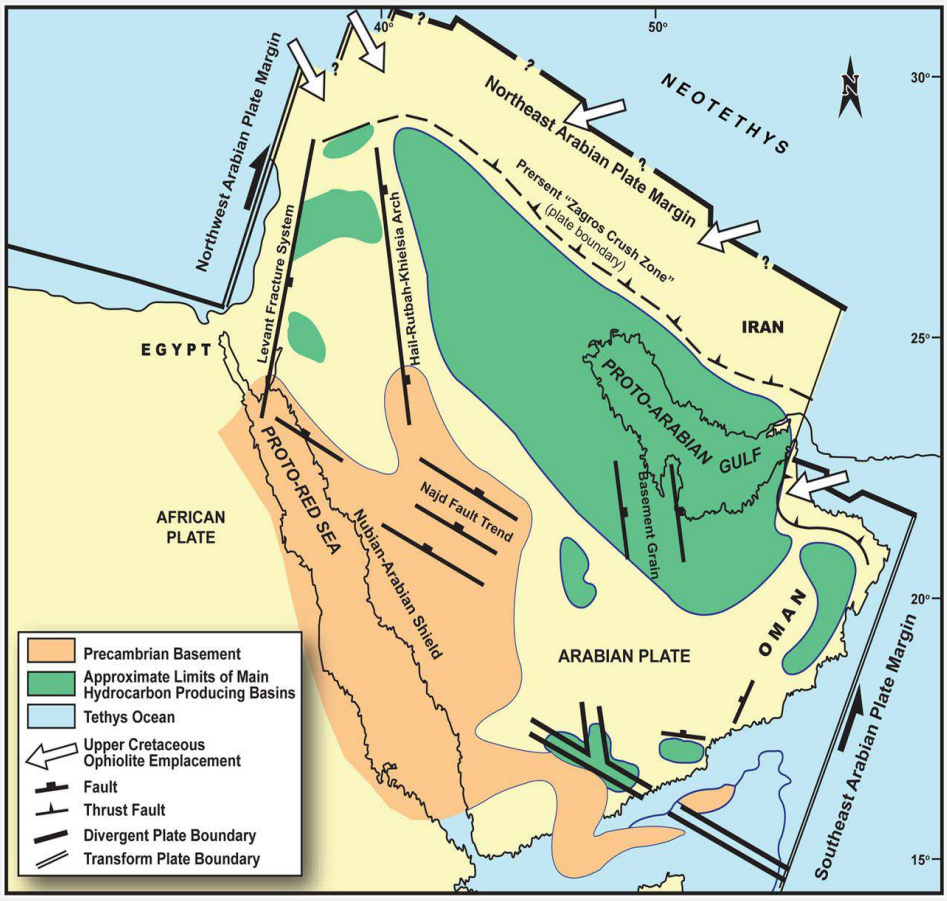
Questions & Answers in Petroleum Systems



Petroleum Systems

1 What is Petroleum Geology?

Petroleum geology is a specific field of geosciences that addresses the origin, distribution, exploration, development, and production of oil and natural gas resources. Petroleum geology involves the analysis of 1) source rocks that are rich in organic matter – the source of oil and natural gas, 2) geological structures and stratigraphic layers that permit accumulations of petroleum to form in the subsurface (traps and seals), and 3) the characteristics of porous subsurface rock formations that store oil and natural gas (petroleum reservoirs).

2 Why Petroleum geology is exciting?

Because one uses many different types of data such as rock cores from wells, well logs that provide information about the rock and fluid properties, and 3D seismic images, all of which are used to develop 2D and 3D maps and models of the subsurface and the distribution of petroleum resources, and to calculate volumes of oil and natural gas that exist in different areas.

3 What is Petroleum?

Petroleum, originated from Greek **Petra** (rock) and Latin **Oleum** (oil), laterally it means **Rock Oil,** is a mixture of natural origin, made of numerous organic molecules, mostly hydrocarbons, from 1 to 80 carbon atoms. Petroleum is found as a liquid phase (oil), a gaseous phase (Natural Gas), or a solid-like phase (bitumen) in the porosity and cracks of reservoir rocks where it has accumulated. These different forms result from a common origin, as petroleum is the product of the thermal or bacterial degradation of sedimentary organic matter in deep strata of sedimentary basins. The range of conditions produces a continuum of compositions between natural gas, oil, and bitumen. It's also known as '**crude oil'** or '**mineral oil'**.

4 What is believed to be the origin of petroleum?

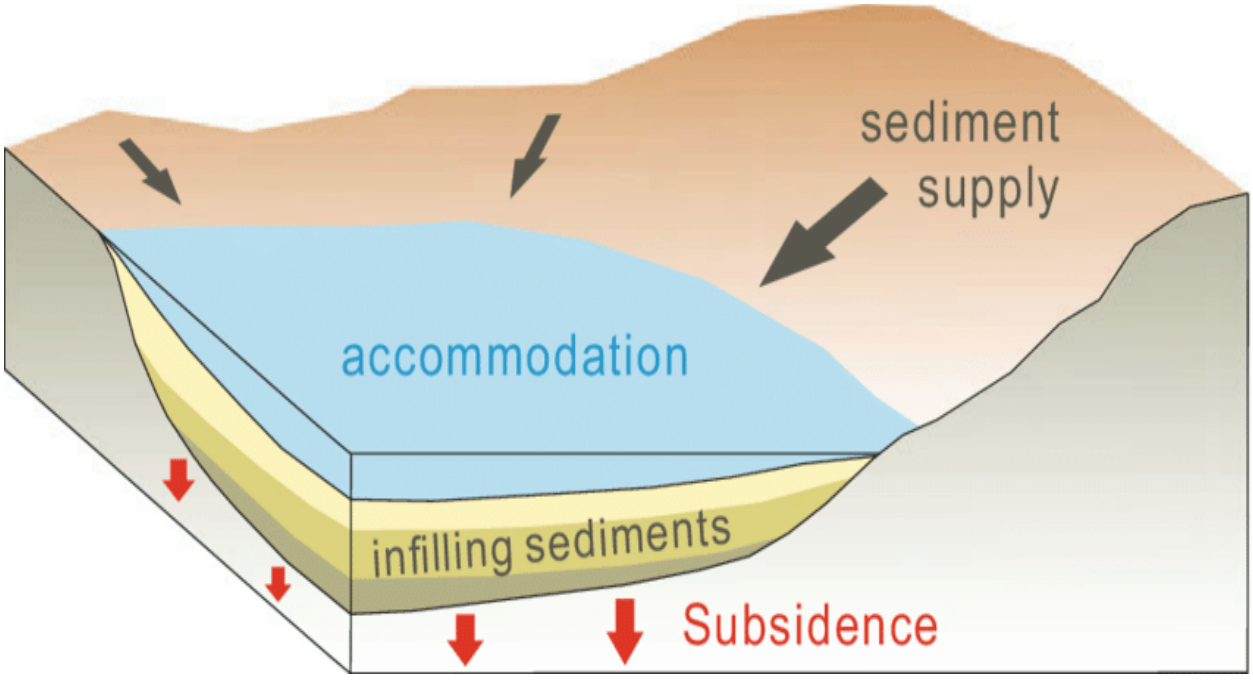
Petroleum is thought to have originated in the remains of marine animals and plant which accumulated sea floors where the water circulation is so slow that little oxygen is present. Bacterial decomposition of the organic matter left residues that consisted chiefly of carbon and hydrogen. There residues were buried under sediments and under the influence of heat and pressure became the lipoid and gaur by carbon compounds that constitute petroleum and natural gas respectively. The oil and gas migrated though porous beds until they either emerged at the surface or were trapped by an impermeable layer. Most petroleum and natural gas are found in Cenozoic and Mesozoic sandstones and carbonate rocks.

5 What is Hydrocarbon?

Hydrocarbon, any of a class of organic chemical compounds composed only of the elements carbon (C) and hydrogen (H). Hydrocarbons are the principa l constituents of petroleum and natural gas. They serve as fuels and lubricants as well as raw materials for the production of plastics, fibres, rubbers, solvents, explosives, and industrial chemicals.

6 What are Sedimentary Basins?

Sedimentary basin is a depression in the crust of the Earth formed by plate tectonic activity in which sediments accumulate. Sedimentary basins, or simply basins, vary from bowl-shaped to elongated troughs (5-10 km deep), If rich hydrocarbon source rocks occur in combination with appropriate depth and duration of burial, hydrocarbon generation can occur within the basin. Basins may be simple or composite (sub-basins). Basins may change in size & shape due to: erosion, sedimentation, tectonic activity, eustatic sea-level changes.

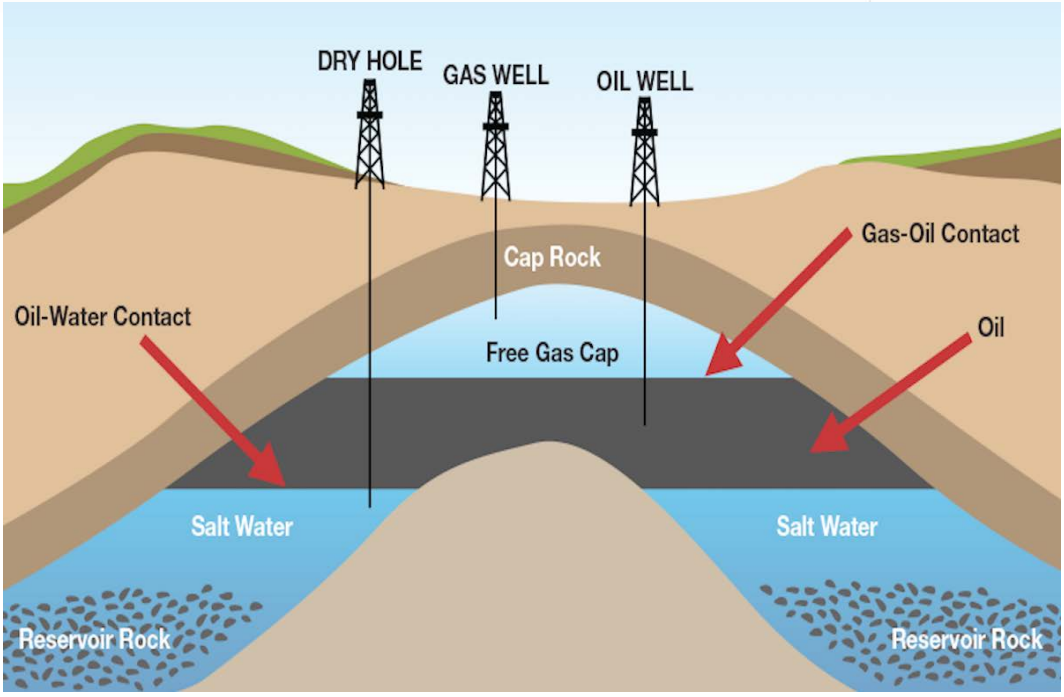


7	What are reservoir rocks?

Reservoir rocks are the rocks that have ability to store fluids inside its pores, so that the fluids (water, oil and gas) can be accumulated. Reservoir rocks have two key characteristics that give them the ability to store fluids: porosity and permeability. A fundamental property of a reservoir rock is its porosity. However, for it to be an effective reservoir rock, the fundamental property is permeability. Reservoir rock must be has good porosity and permeability to accumulate and drain oil in economical quantities.

8	What is a Reservoir?

In petroleum geology**, reservoir** is one of the elements of petroleum system that can accumulate hydrocarbons (oil or gas). is a porous and permeable formation contained within a trap. (must have hydrocarbon, porosity, organic material and surrounded by rock matrix).



9 **What is the distinction between the porosity and the permeability?**

Porosity refers to the relative volume of pore space in a rock bed; the greater the porosity of a bed; the greater the porosity of a bed. The more water it can contain. **Permeability** refers to the ease with which water can move through a rock bed; the greater the permeability of a bed, the faster water can flow through it . **Both porosity and permeability** are geometric properties of a rock and both are the result of its lithologic (composition) character. The physical composition of a rock and the textural properties (geometric properties such as the sizes and shapes of the constituent grains, the manner of their packing) are what is important when discussing reservoir rocks and not so much the age of the rock.

10 What are Reservoir rock properties?

Vp = VB - VS, **Φ** symbolizes porosity, **Vp** (volume of all pores), **Vs** represents volume occupied by other particles (Matrix materials), **VB** represents the total volume, **p** represents their respective densities.

11 What is Reservoir Porosity?

Porosity is the void space in a rock that can store the fluids. It is measured as either a volume percentage or a fraction (expressed as a decimal). In the subsurface this volume may be filled with petroleum (oil and gas), water, a range of non hydrocarbon gasses (CO_2, H_2S, N_2), or some combination of these. [1]Porosity is symbolized in phi (ϕ) and its value is expressed in percentage. Porosity value calculation:

(ϕ) = Pore Volume / Bulk Volume X 100 %

12 What are types of Porosity?

Porosity divided into two types, **absolute porosity** and **effective porosity**. **Absolute porosity** is the ratio of the total pore volume in the rock to bulk volume, obtained by

(ϕ_a) = Total Pore Volume / Bulk Volume X 100 %

Effective porosity is the ratio of interconnected pore volume to bulk volume, obtained by

(ϕ_e) = Total Interconnected Pore Volume / Bulk Volume X 100 %

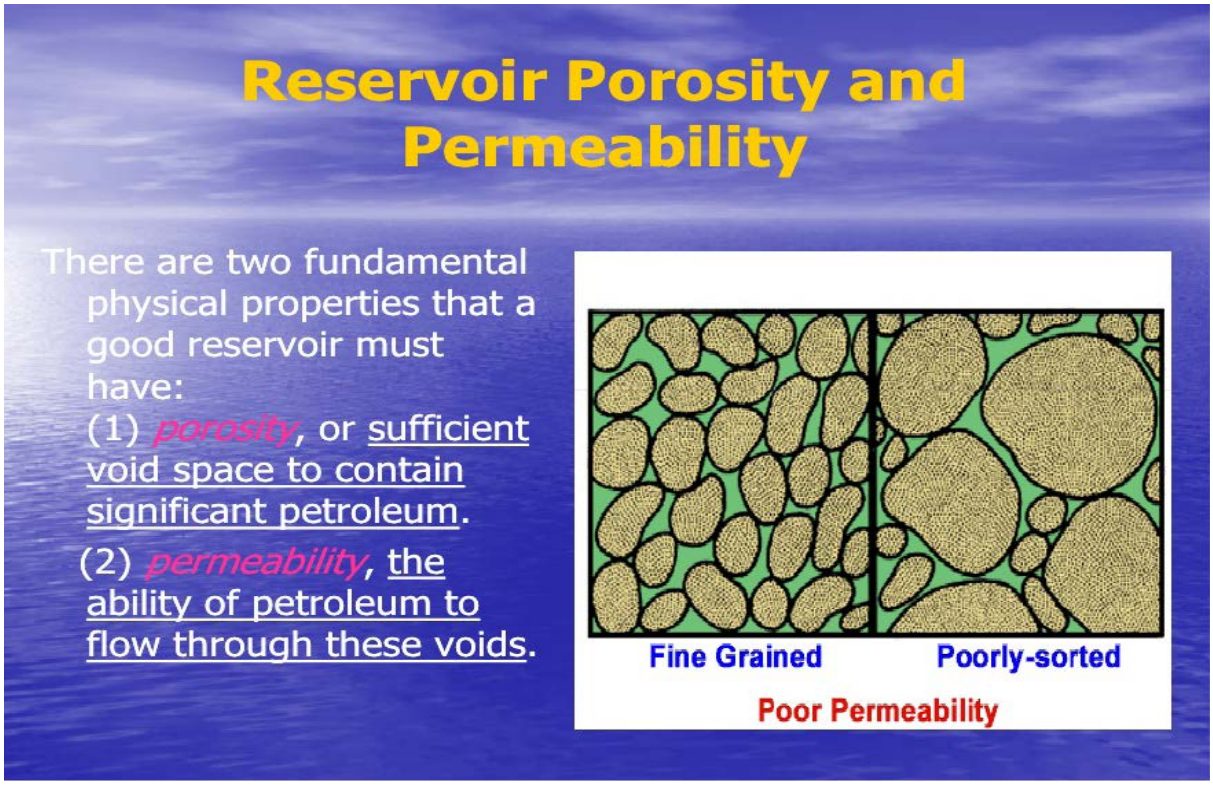
Based on the way of its formation, there are two types of porosity:

Primary porosity is porosity that formed while sedimentary rock deposited.

Secondary porosity is porosity that formed after the sedimentary rock deposited.

13 What is Permeability of reservoir?

Permeability is a measure of the ability of a fluid to pass through its porous medium. Permeability is one of important to determine the effective reservoir. A reservoir rock can be porous without being permeable. For example it is said to be permeable if and only if the pores "communicate". Knowing reservoir rock permeability is a key milestone because it is important for being used to determine if it really has sufficient commercial accumulation of oil, indeed measuring it is very difficult. In the petroleum industry, the Darcy (D) is the standard unit of permeability, but milidarcies (1 mD = 10^{-3} D) are more commonly used. A Darcy is defined as a flow rate of 10^{-2} ms^{-1} for a fluid of 1 cp (centipoise) under a pressure of 10^{-4} atm m^{-2}. Permeability in reservoir rocks may range from 0.1 mD to more than 10 D.



14 How to measure Permeability?

The measuring of permeability can differently be understood basing on two different ways. When the porous medium is completely saturated by a single fluid, the permeability will be described absolute, become described as effective permeability when its porous medium is occupied by more than one fluid. Determining the flow of a fluid depends on constan**, k** , Darsey constant. With **q** representing flow rate, **A** the area section of pores, **μ** represents viscosity constant of fluid and **dp/ dL** represents the infinitesimal change of flowing pressure.

15 What are Types of reservoir rocks?

As a rock to be named a reservoir has to be a porous and permeable lithological structure. It encompasses sedimentary rocks. These sedimentary rocks may be made of **sandstones** (quartz sand or arksosic sandstone), **carbonates** mud or **dolomite**. Dolomites mostly form good reservoirs because the common reason behind it is that there is Mg, 13% smaller than Ca in a way that during dolomitization, there is a total decrease in volume of the material by 13%, here by 13% porosity is gained.

16 What is Lacustrine Reservoir?

This type of reservoir formed in basin containing water surrounded by land and initially formed by tectonic processes, volcanic, rifting, soil movement, and the erosion by the wind on the coast or in land. The texture of sedimentary rocks in the environments usually granules grained and the size between 2 mm –4 mm.3.2.6.

17 What is Eolian Reservoir?

Formed in large areas with the accumulation of sand deposition. The sediment resulting from wind-blown sand. The clastic texture of the environment is granules (2 mm –4 mm) and coarse (over 2 mm)

18 What is meant by petroleum traps?

Trap is an **impermeable** structure that acts as a container for hydrocarbons such as domes or fault blocks. Hydrocarbon traps form where permeable reservoir rocks (carbonates, sandstones) are covered by rocks with low permeability (caprocks) that are capable of preventing the hydrocarbons from further upward migration. Typical caprocks are compacted shales, evaporites, and tightly cemented sandstones and carbonate rocks.

19 What are Types of Petroleum Traps?

Two types of petroleum traps are; structural and stratigraphic.

Structural traps are formed by deformation of reservoir rock, such as by folding or faulting.

Stratigraphic traps are formed by deposition of reservoir rock, such as river channel or reef, or by erosion of reservoir rock, such as an angular unconformity.

20 What are structural traps?

Structural trap is a type of geological trap that forms as a result of changes in the structure of the subsurface, due to tectonic, diapiric, gravitational and compactional processes. These changes block the upward migration of hydrocarbons and can lead to the formation of a petroleum reservoir. Structural traps are the most important type of trap as they represent the majority of the world's discovered petroleum resources. The three basic forms of structural traps are the **anticline trap**, the **fault trap** and the **salt dome trap.**

21 What is Salt dome Trap?

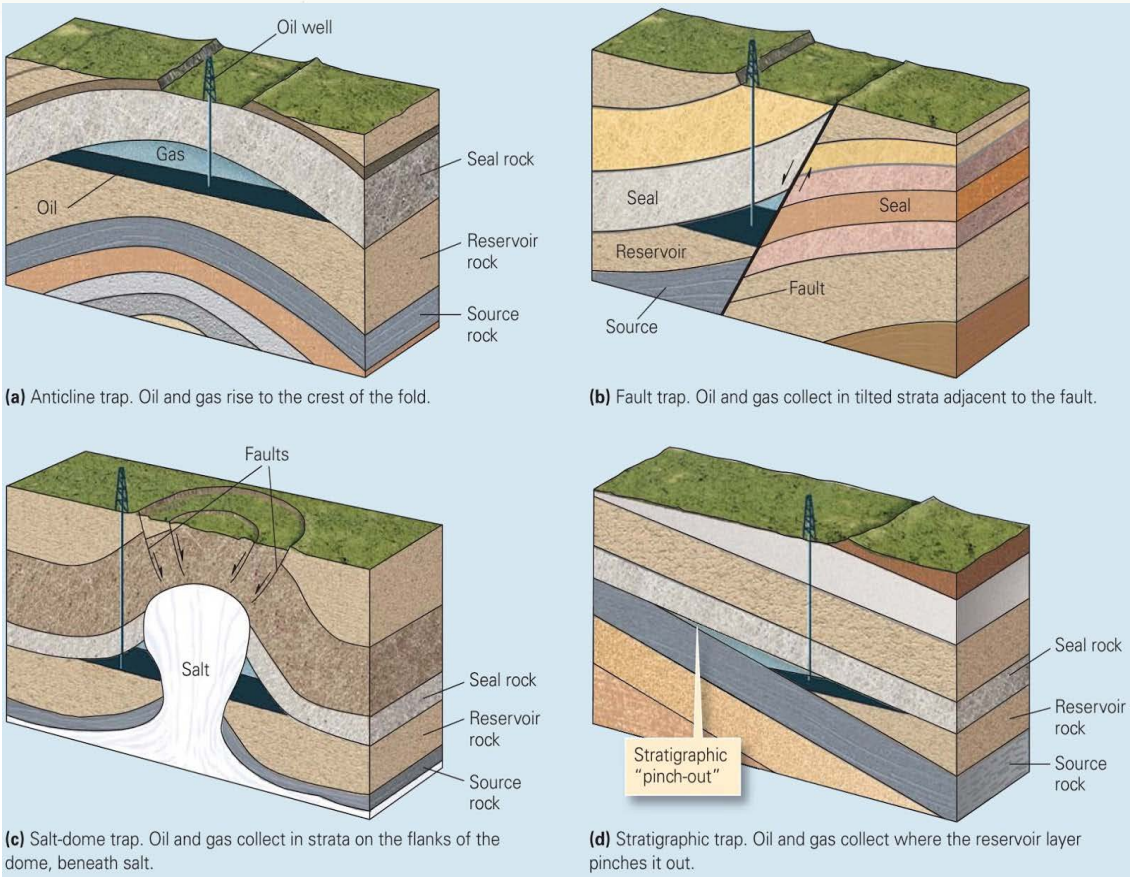
Masses of salt are pushed up through clastic rocks due to their greater buoyancy, eventually breaking through and rising towards the surface (see salt dome). This salt is impermeable and when it crosses a layer of permeable rock, in which hydrocarbons are migrating, it blocks the pathway in much the same manner as a fault trap. This is one of the reasons why there is significant focus on subsalt imaging, despite the many technical challenges that accompany it.

22 What is the difference between Anticline traps and Fault traps?

Anticlinal (fold) Trap. An anticline is an area of the subsurface where the strata have been pushed into forming a domed shape. If there is a layer of impermeable rock present in this dome shape, then hydrocarbons can accumulate at the crest until the anticline is filled to the spill point – the highest point where hydrocarbons can escape the anticline. This type of trap is by far the most significant to the hydrocarbon industry. Anticline traps are usually long oval domes of land that can often be seen by looking at a geological map or by flying over the land. **Fault Trap**. This trap is formed by the movement of permeable and impermeable layers of rock along a fault line. The permeable reservoir rock faults such that it is now adjacent to an impermeable rock, preventing hydrocarbons from further migration. In some cases, there can be an impermeable substance smeared along the fault line (such as clay) that also acts to prevent migration. This is known as clay smear.

23 What are divisions of Stratigraphic Traps?

Stratigraphic traps are formed as a result of lateral and vertical variations in the thickness, texture, porosity or lithology of the reservoir rock. Examples of this type of trap are an unconformity trap, a lens trap and a reef trap.



(a) Anticline trap. Oil and gas rise to the crest of the fold.

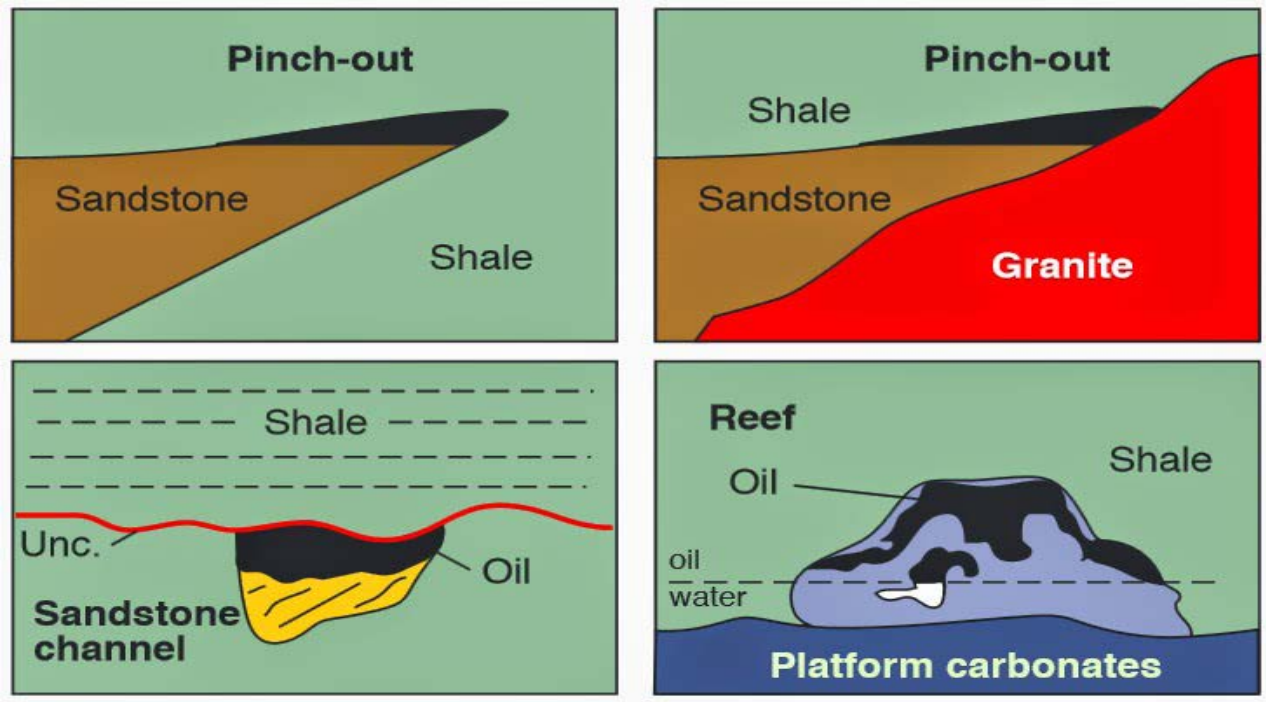
(b) Fault trap. Oil and gas collect in tilted strata adjacent to the fault.

(c) Salt-dome trap. Oil and gas collect in strata on the flanks of the dome, beneath salt.

(d) Stratigraphic trap. Oil and gas collect where the reservoir layer pinches it out.

24 How to recognize the two main group of stratigraphic traps?

Two main groups are : **Primary** stratigraphic traps result from variations in facies that developed during sedimentation. These include features such as lenses, pinch-outs, and appropriate facies changes.
Secondary stratigraphic traps result from variations that developed after sedimentation, mainly because of diagenesis. These include variations due to porosity enhancement by dissolution or loss by cementation. Paleogeomorphic traps are controlled by buried landscape. Some are associated with prominences (hills); others with depressions (valleys). Many are also partly controlled by unconformities so are also termed unconformity traps.



25 What are Diapiric and diagenetic Traps?

Diapiric traps are density-driven flow of rock materials, under pressure i. Salt Diapirs ii. Mud Diapirs.

Diagenetic Traps are low-permeability seal zones created by diagenetic alteration which are:

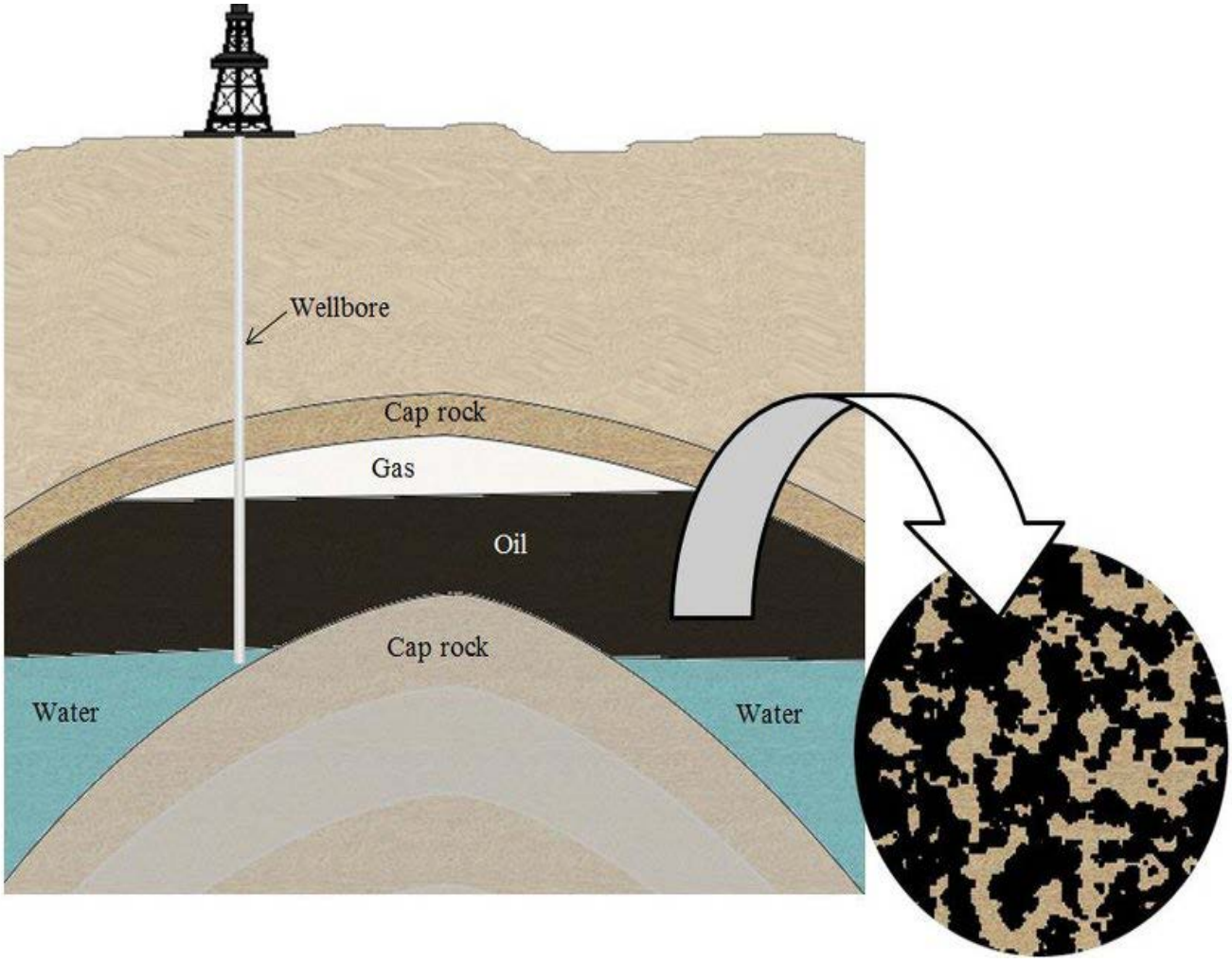
1. preferential cementation.
2. clay aleration.
3. Dolomitization.

26 What is Seismic Stratigraphy?

It is the study of seismic data for the purpose of extracting stratigraphic information. Seismic stratigraphy is often divided into several sub-areas:
Analysis of seismic sequence (Separating out time-depositional units based on detecting unconformities or changes in seismic patterns).
Analysis of seismic facies (Determining depositional environment from seismic reflection characteristics);
Analysis of reflection character (Examining the lateral variation of individual reflection events, or series of events, to locate where stratigraphic changes occur and identify their nature; the primary tool for this is modeling by both synthetic seismograms and seismic logs).

27 What is meant by Cap (Seal) rock?

Cap rock is a rock that prevents the flow of a given fluid at a certain temperature and pressure and geochemical conditions. There are several types of cap rock:
Type1: caprocks are typical for argillaceous sequences in a state of continuing compaction.
Type2: caprocks are associated with rocks compacted beyond the plasticity limit and having lost ability to swell on contact with water. Such rocks do not contain swelling clay minerals.
Type3: caprocks are typical for rocks with a rigid matrix and intense fracturing. Such caprocks are mainly developed over the old platforms in regions of low tectonic mobility.

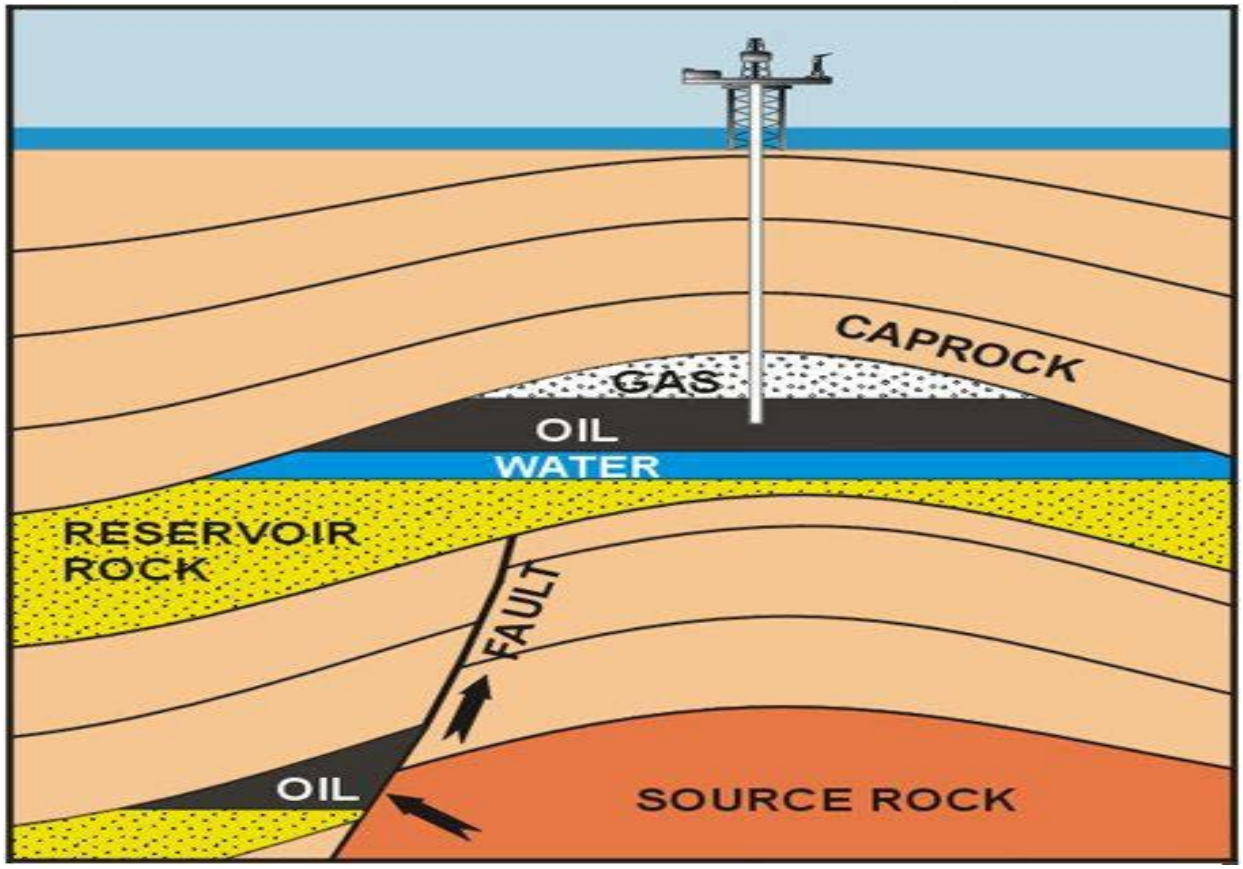

Wellbore
Cap rock
Gas
Oil
Cap rock
Water
Water

28 **What are geological requirements for the formation of a conventional hydrocarbon reservoir?**

1	Source Rock
2	Migration Path
3	Cap Rock
4	Reservoir Rock
5	Trap

29 **What is a source rock?**

A source rock is a rock that can generate natural gas and/or crude oil. They form one of the necessary elements of a working petroleum system. They are organic-rich sediments that may have been deposited in a variety of environments. Oil shale can be regarded as an organic-rich but immature source rock from which little or no oil has been generated and expelled. Subsurface source rock mapping methodologies make it possible to identify likely zones of petroleum occurrence in sedimentary basins.



30 What are the categories of source rocks?

Source rocks can be divided into at least four major categories:

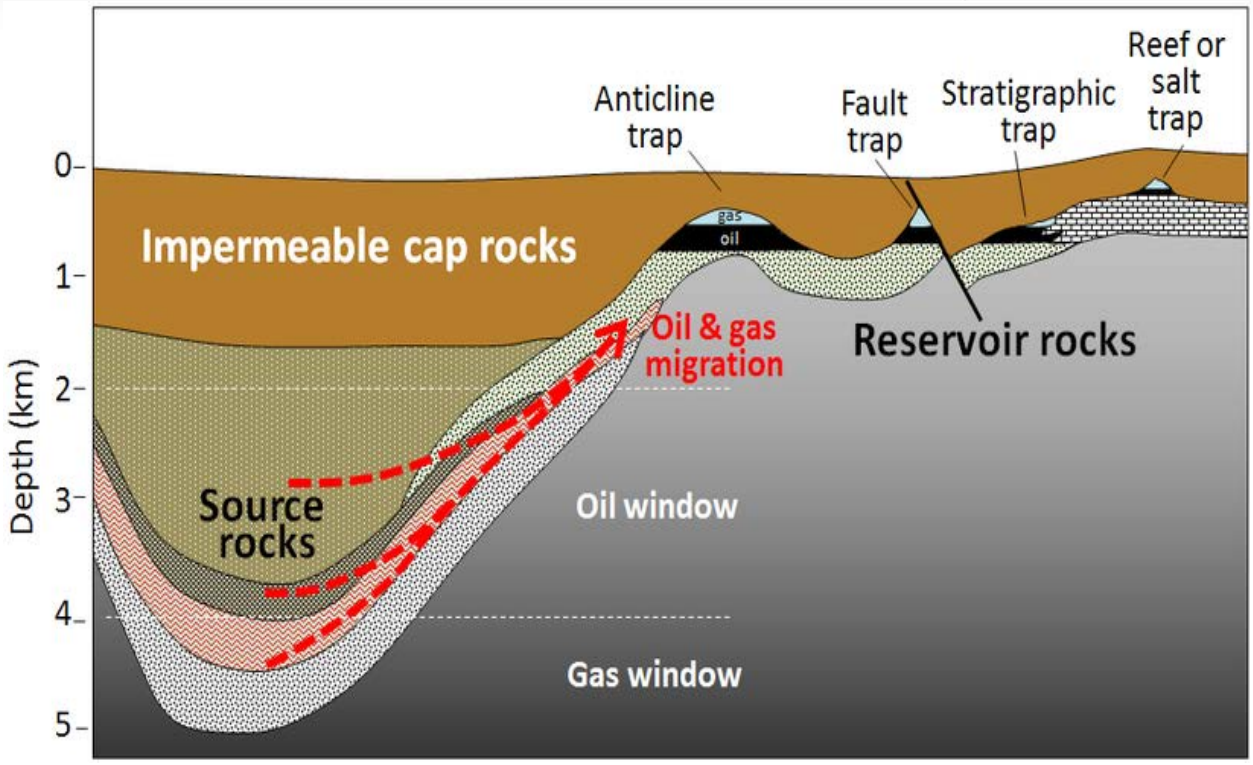
1	Potential	3	Cap Rock
2	Effective	4	Spent

31 What is the characteristic of source rocks?

To be a Source rocks, must have three features:
1. Quantity of organic matter
2. Quality capable of yielding moveable hydrocarbons
3. Thermal maturity

32 What are Types of source rocks?

Source rocks are classified from the types of kerogen that they contain, which in turn governs the type of hydrocarbons that will be generated.
A. Type 1 source rocks are formed from algal remains deposited under anoxic conditions in deep lakes: they tend to generate waxy crude oils when submitted to thermal stress during deep burial.
B. Type 2 source rocks are formed from marine planktonic and bacterial remains preserved under anoxic conditions in marine environments: they produce both oil and gas when thermally cracked during deep burial.
C. Type 3 source rocks are formed from terrestrial plant material that has been decomposed by bacteria and fungi under oxic or sub-oxic conditions: they tend to generate mostly gas with associated light oils when thermally cracked during deep burial. Most coals and coaly shales are generally Type 3 source rocks.



33 How gas and oil formed?

Gas and oil formed from ancient organic matter preserved in sedimentary rocks. As sediments are deposited, both inorganic mineral grains, such as sands and mud, and organic matter (dead plants and animals) are mixed. Most organic matter is lost on the surface by decay, a process of oxidation. The decaying organic matter on land gets oxygen from the air, and the decaying organic matter on the ocean bottom gets the oxygen from out of the water. Some organic matter, however, is preserved. It was either rapidly buried by other sediments before it decayed or was deposited on the bottom of a sea with stagnant, oxygen-free waters

34 What is Natural Gas?

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, with up to 20% concentration of the other hydrocarbons (usually ethane) as well as small amounts of impurities such as carbon dioxide. Natural gas usually consists mostly of methane (CH4) but may contain variable amounts of higher-order paramns (ethane, propane and butane). Natural gas is odorless, colorless and lighter than air and produces very few emissions. It is considered the cleanest fossil fuel because of its clean-burning qualities. **Dry gas** is predominantly methane and ethane, while "Wet gas" contains more than 50% propane and butane.

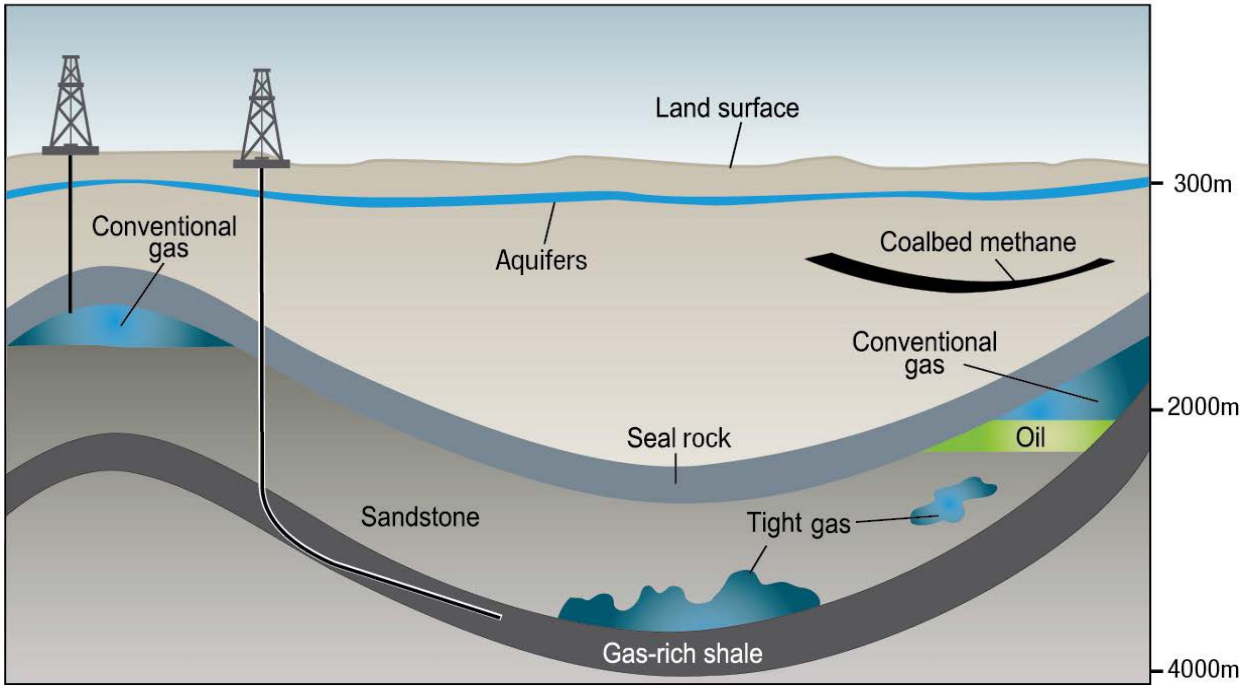
35 What is the use of natural gas?

Natural gas is used for power generation and as feedstock for fertilizer plants and fuel for industrial use etc. It is also used for heating, hot water, cooking and outdoor living. It is becoming a fuel of choice in domestic and commercial sectors.

36 Does use of natural gas affect the environment?

Natural gas is one of the cleanest-burning fossil fuels; complete combustion produces mainly water vapor and carbon dioxide. The amount of greenhouse gas released from natural gas is significantly lower than emissions from wood, coal and oil. When natural gas replaces these other fuels, emissions of greenhouse gases are significantly reduced.

SCHEMATIC GEOLOGY OF NATURAL GAS RESOURCES



37 What is fossil fuel?

Fossil fuels, any hydrocarbon substance taken from natural resources which were formed from biomass in the geological past, burned as a source of heat or power. The heat is derived from the combustion process in which carbon and hydrogen in the fuel substance combine with oxygen and release heat.

38	How Seismic Stratigraphy works?

use of exploration seismology to determine 3-D rock geometries and associated temporal relations. a. General Basis: Seismic waves induced through rock using artificial source (e.g. explosive or vibrational source), waves pass through rock according to laws of wave physics, “geophones” record waves and their characteristics (1) Seismic wave behavior influenced by rock type, structure, bed geometries, internal bedding characteristics b. “Seismic Facies”: seismic wave patterns used to interpret rock type, lithology, structure, bed geometries.

39 What are Principal Seismic Facies Configurations?

(1) Parallel configurations
(2) Divergent configurations
(3) Progradational configurations
(4) Mounded/draped configurations
(5) Onlap/fill configurations

40 What are the four main divisions of the value chain of the upstream aspect of the oil and gas industry?

1. Frontier Exploration. “Should we explore this area?”
2. Exploration and Exploitation. Find structures.
3. Appraisal . How much oil is present?
4. Development & Production. Drill wells and produce oil.

41 What is the difference between crude oil and petroleum products?

Crude oil is a mixture of hydrocarbons that exists as a liquid in underground geologic formations and remains a liquid when brought to the surface.
Petroleum products are produced from the processing of crude oil and other liquids at petroleum refineries, from the extraction of liquid hydrocarbons at natural gas processing plants, and from the production of finished petroleum products at blending facilities.

42 What is the difference between Natural Gas and LPG?

Natural gas is in gaseous form whereas LPG is in liquid form. Storage and transportation of natural gas in liquid form requires greater infrastructure whereas LPG can be stored in lesser infrastructure i.e. 5 kg/14 kg cylinders and can be transported through trucks, lorries etc., Therefore LPG is available in rural areas also. In addition, LPG produces greater heat due to its higher calorific value.

43 How is natural gas stored?

Natural gas can be stored in different ways. It can be stored underground. Natural gas is also stored as LNG after it is liquefied and can be stored in above/ below ground storage tanks. It can also be stored in pipelines temporarily.

44 What is LNG?

Liquefied natural gas, or LNG, is natural gas in its liquid form. When natural gas is cooled to- 161 degrees Celsius, it becomes a clear, colorless, odorless liquid. LNG is neither corrosive nor toxic. Natural gas is primarily methane, with low concentrations of other hydrocarbons, water, carbon dioxide, nitrogen, oxygen and some sulfur compounds. During the process known as liquefaction, natural gas is cooled below its boiling point, removing most of these compounds. The remaining natural gas is primarily methane with only small amounts of other hydrocarbons. LNG weighs less than half the weight of water so it will float if spilled on water.

45 **Explain: Net to Gross?**

The "net-to-gross ratio" or "net/gross" (**N/G**) is the total amount of pay footage divided by the total thickness of the reservoir interval (for simplicity, the well is assumed here to be vertical). A N/G of 1.0 means that the whole of the reservoir interval is pay footage

46 **What are Organic Components of Living Organisms?**

- Proteins – amino acids (animals primarily)
- Carbohydrates – sugars (animals and plants)
- Lignin – aromatics (higher order plants)
- Lipids – insoluble fats (animals and plants)

47 **What is the relation of Thermal Maturation of Hydrocarbons as a Function of Depth and Temperature?.**

With increasing depth and temperature Hydrogen and oxygen are expelled as water Carbon content in organic molecules increases. Higher order / higher molecular weight Hydrocarbons are produced.

48 What is the process of primary migration of Hydrocarbons from source to reservoir?

Primary Migration :

1. Migration of hydrocarbons from source rock (organic-rich clay or shale) into permeable reservoir rock (sands, sandstones, limestones/dolomites)

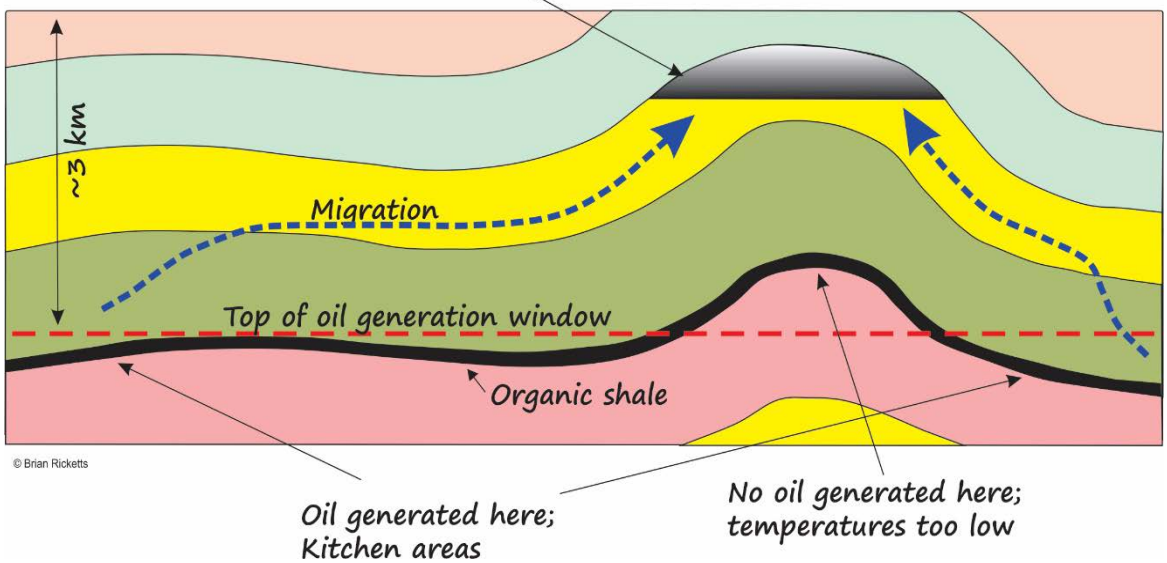
2. "**MIGRATION PARADOX**" – source rocks involve thermally heated, organic, impermeable clays, muds/shales undergoing compaction over time... how do the fluids migrate out of the source rocks in such low permeability conditions at the maturation stage?

Controlling factors of Hydrocarbons migration are:

1. Timing of generation and migration.
2. Physical parameters of source bed (temperature, pressure, permeability, porosity).
3. Chemical composition of source bed (organics and mineralogy).
4. Timing of kerogen transformation to oil and gas.
5. Mixture of migrating fluids: combinations of water, oil, gas.
6. State of fluids: liquid, gas, dissolved gases.

Typical oil migration pathways and trapping

Folded strata; sandstone is overlain by impermeable mudstone. Oil is TRAPPED at the apex of the fold. Gas will accumulate above the oil.



49 Classify Organic Sediment?

Organic sediments are classified to : Marine and Non-Marine
Bitumen – soluble organic matter
Kerogen – insoluble organic matter
Marine Organics: algal, soft parts, petroleum generation
Terrestrial Organics: woody plants, gas generation
Mixed Marine-Terrestrial: waxy oil-gas mix

50 What are specific conditions for petroleum accumulation?

1. Organic source rock
2. Sediment burial and thermal maturation (heating over time)
3. Permeable and Porous reservoir rock to store fluids
4. Cap rock or impermeable seal to contain buoyant fluids
5. Favorable geometric arrangement between reservoir and seal

51 What percentages of Hydrocarbon Compounds in Petroleum:

> 200 organic carbon-based compounds

1. Paraffins: gaseous at surface temperatures **(25 % by weight)**
2. Napthenes: liquid at surface temperatures **(50 % by weight)**
3. Aromatics: ring-based compounds **(17 % by weight)**
4. Asphaltics: heavy oil and tar **(8 % by weight)**

52 What is Facies and Facies Association?

Facies is a body of rock characterized by a particular combination of lithology, physical and biological structures that bestow an aspect ("facies") different from the bodies of rock below, above, and laterally adjacent.

Facies Association—"groups of facies genetically related to one another and which have some environmental significance.

53 What is Walther's Law?

The observation that when environments change position, adjacent sedimentary facies will succeed each other in vertical depositional sequences. Vertical changes in lithology due to transgression or regression are mirrored by similar lateral changes (e.g., coarsening laterally as well as upward. In other words, facies that occur in conformable vertical succession of strata also occur in laterally adjacent sedimentary environments.

54 Give Examples of Sedimentary Rocks related to depositional environments?

Sandstones vary in quartz content, grain rounding & matrix percentage)

a. Quartz sandstone- predominantly quartz grains ("clean sandstone"). Long transportation (quartz survives long transportation because it is relatively hard). Distant from mountainous regions, tectonically stable. Often form at coastlines (e.g. beaches), in deserts, on higher energy coastal plains and river floodplains (e.g. Padre Island). Quartz grains make up 90%+ of rock and the grains are well rounded. Cross beds and ripples are common.

b) Arkose – terrestrial (i.e nonmarine) ; derived from granitic highlands, contain > 25% feldspar grains (implies fairly short transportation, because feldspar is relatively soft and erodes over long distances). Commonly pink-red color.

SHALES: Form in similar environments to sandstones, only deposited under lower energy conditions (i.e. "quieter" locations)-> finer particles (clay, silt). Shallow marine, marshes, lakes, lower energy coastal plains and floodplains. Finely layered, often fissile. Common fossils.

C. Graywacke – mixture of sand, clay and rock fragments ("dirty sandstone"). Indicates tectonic activity, rapid erosion/sediment accumulation in deep marine settings at the edges of continental slopes and at the bottom of oceanic trenches, short transportation. Often deposited as turbidites (submarine landslide deposits). Matrix is usually 30%. Beds are often graded (sorted by size- coarse at the base, finer at the top).

d) lithic sandstone- typical of deltaic deposits e.g. Mississippi delta. Matrix < 15%. Transitional between quartz sandstones and graywackes. **Matrix**—the finer-grained material enclosing, or filling the interstices (pores or spaces) between the larger grains or particles of a sediment or sedimentary rock.

55 What are the environments of petroleum formation?

Environments that preserve unusually large amount of organic matter in the sediments are:

Stagnant lakes and silled basins, where the bottom waters are strongly reducing, as in black sea. In such areas, the organic content of the sediments frequently exceeds 15%.- At the other extreme are the red clays of the oceanic abyssal plains, where slow rates of deposition, aerobic waters, and little contribution of organic matter results in sedimentary organic content less than 0.1%.

Red Clay: A pelagic deposit that is fine-grained and reddish brown or chocolate-colored, formed by the slow accumulation of material a long distance from the continents and at depths generally greater than 3500 meters.

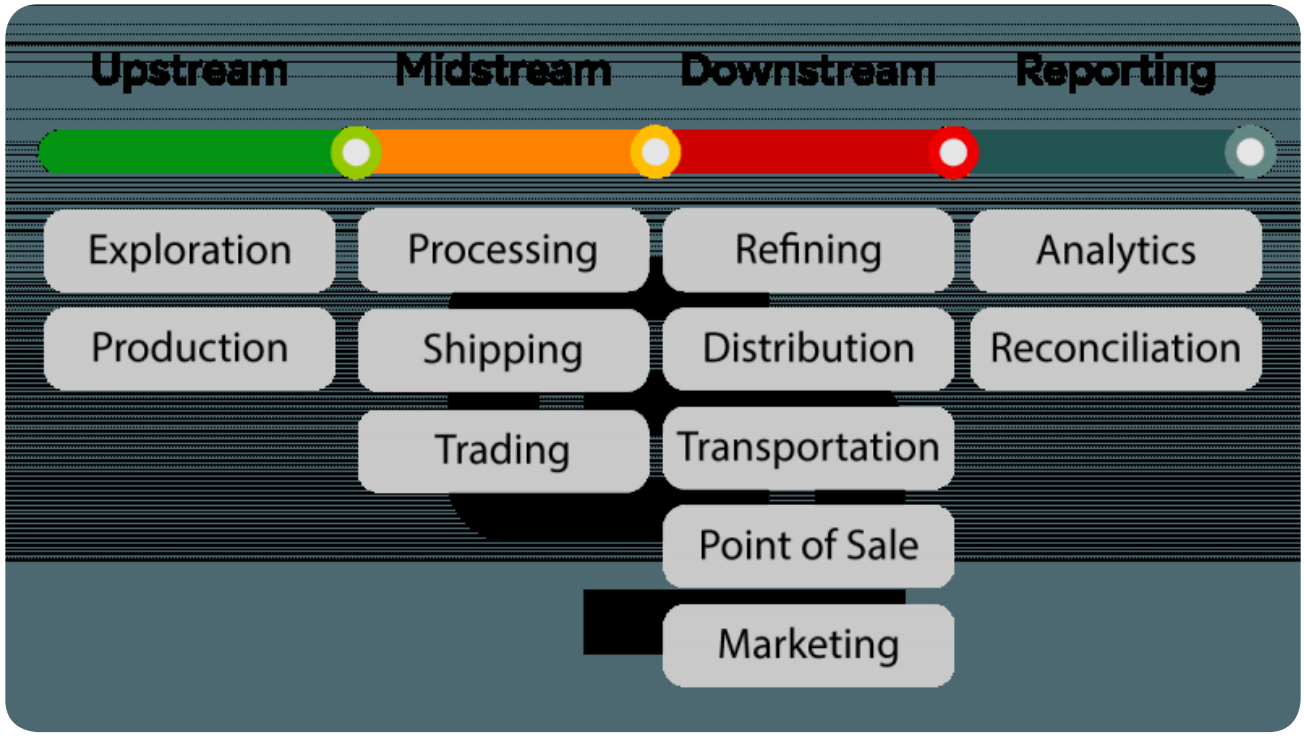
Diagenesis of organic matter: Neither of these extremes is typical of most petroleum-forming environments- Oil is formed from the organic matter deposited in the aerobic waters of sedimentary basins, where the water occasionally may be locally anaerobic, but the sediments are nearly always anaerobic . The more resistant organic matter, including humid materials, resins, waxes and lipids are preferentially preserved. The organic content of such sediments, which finally become source beds of petroleum, generally ranges between about 0.5 and 5%, with a mean around 1.5%.

56 What is Metagenesis and metamorphism?

The last stage of the evolution of sediments, which is known as **metamorphism**, is reached in deep troughs and in geosynclinals zones. Petroleum geology is only concerned with the stage pre-occurring metamorphism and it is referred to this stage preceding metamorphism as metagenesis of organic matter. Minerals are severely transformed under those conditions, clay minerals lose their interlayer water and gain a higher stage if crystallinity, iron oxides containing structural water (goethite) change to oxides without water (hematite), severe pressure dissolution and recrystallization occur, like the formation of quartzite.

57 What is the upstream oil and gas segment?

This is also known as the exploration and production (E&P) sector because it encompasses activities related to searching for, recovering and producing crude oil and natural gas. The upstream segment is all about wells: where to lo cate them; how deep and how far to drill them; and how to design, construct, operate and manage them to deliver the greatest possible return on investment with the lightest, safest and smallest operational footprint.



58 How much Energy Resources of the World?

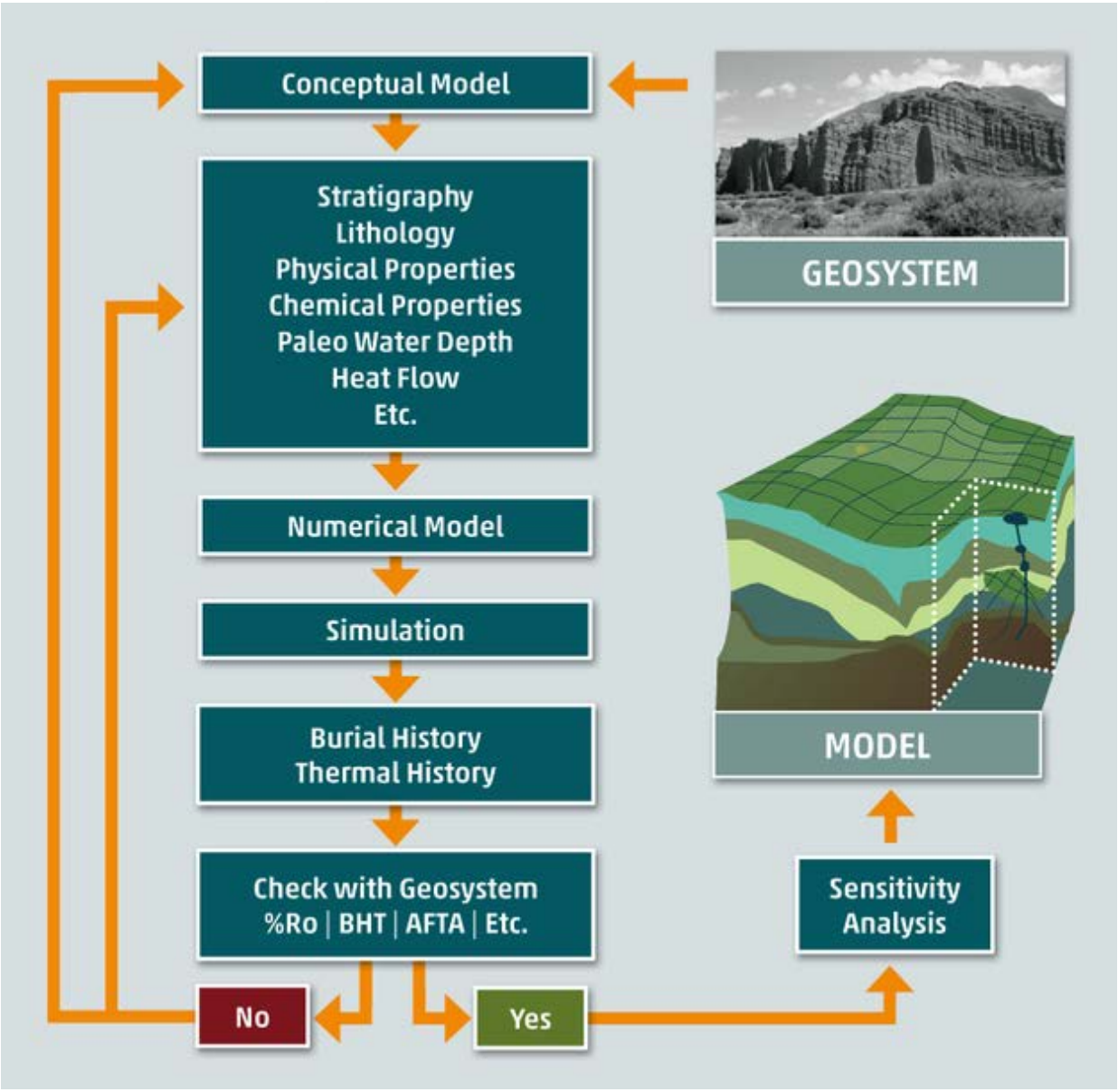
Coal 21%, **Oil** 32 %, **Natural Gas** 23 %, **Nuclear Power** 6 %, Hydropower/ Geothermal/Solar/ Wind 7%
Oil Shales: Enriched in Organic matter "fine grained" Shale
Oil: petroleum oil we get from Oil shale "Tight oil = Crude oil"

59 What is Mineraloid and Kerogen?

Kerogen is Solid mixture of organic chemical compounds. Tar Sands: type of unconventional petroleum deposits.
Mineraloid is a naturally occurring, usually inorganic substance that is not considered to be a mineral because it I amorphous and lacks characteristic crystal form**.**

60 What is the Petroleum System?

It's a relation between accumulation "Surrounding places of generation" and place of generation. Or Elements and processes related to generation, migration and trapping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Chemical Properties
Paleo Water Depth
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Simulation
Burial History
Thermal History
Check with Geosystem
%Ro | BHT | AFTA | Etc.
No
Yes
GEOSYSTEM
MODEL
Sensitivity Analysis

61 What are Amber and Chalcedony?

Amber is a fossilized tree resin, which has been appreciated for its color and natural beauty since Neolithic. **Chalcedony** is a cryptocrystalline form of silica, composed of very fine intergrowths of the mineral's quartz and moganite, these are both silica minerals, but they diNer in that quartz has a trigonal crystal structure, while moganite is monoclinic

62 What is the Direct detection of Hydrocarbon?

I. Bright Spots.- It is one of the pattern classes in a seismic section and the indicators of gas (hydrocarbon) accumulation.
II. 3D Seismic.- A technology that has significantly changed energy exploration.
III. 4D Seismic- Time represents the fourth dimension.
IV. Seismic Stratigraphy

63 What are Measurement Units in Petroleum?

1 barrel = 159 liters, 1 **cubic meter** = 6.37 barrels, 1 **metric ton** = 6.8 to 7.6 barrels (dep. on gravity), Gas is expressed in millions of Cubic feet: 1 MMcf ≈ $3x10^4$ m^3- Energy-wise, gas can be expressed in oil equivalents:- 1 boe ≈ 6000 to 6500 cf

64	What are Top 5 countries in gas production?
	They are USA, Russia, Iran, Canada, Qatar

65	What is sapropel?
	Sapropel is jellylike ooze or sludge composed of plant remains, most often algae, putrefying in an anaerobic environment on the shallow bottoms of lakes and seas. It may be a source material for petroleum and natural gas. A mud rich in organic matter formed at the bottom of a body of water. A fluid slime found in swamps as a product of putrefaction. Sapropel is used in marine geology to describe dark-colored sediments that are rich in organic matter. Organic carbon concentrations in sapropels commonly exceed 2% in weight.

66 What are Elemental composition of Petroleum?

Main Elements: Hydrogen/Carbon.

Minor Elements: Sulfur, Nitrogen and Oxygen.

Trace Elements: e.g. Phosphorus, Vanadium and Nickel.

Chemical Composition, Gas: 1-4 carbons, Liquid: 5-15 carbons, Solid: above 15 carbons

67 What is meant by Hydrocarbon series?

The hydrocarbons have been divided into various series, diNering in chemical properties and relationships. The four that comprise most of the naturally occurring petroleum are:

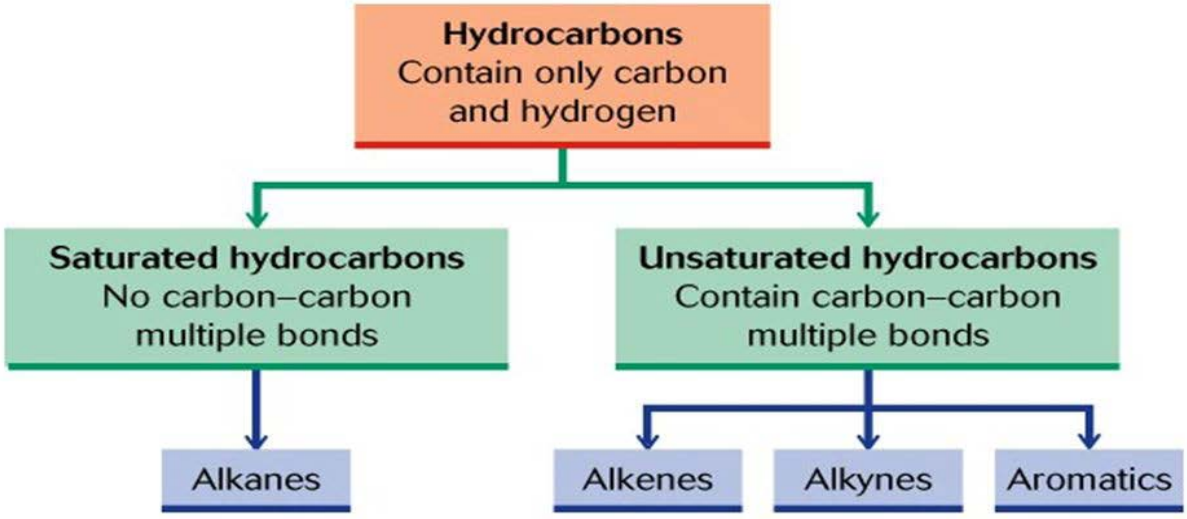
The Normal paraFn (or alkanes) series. C_nH2_{n+2} They are the second most common constituents of crude oil next to naphthene's. Paramns dominate the gasoline fraction of crude oil, and they are the principal hydrocarbons in the oldest, most deeply reservoirs.

The Iso-paraFn series (or branched-chain paramn).

The Naphthene (or cycloparamn) series. CnH2nThe most common molecular structures in petroleum. Sour crudes: % of Sulfur is H=high.

The Aromatic (or benzene) series. C_nH_{2n-6} Benzene is a colorless and a volatile liquid, is the parent and most common member of the series found in petroleum. While aromatics are present in all petroleum, the percentage is generally small

The Families of Hydrocarbons: alkanes, alkenes, alkynes, and aromatics



68 What is the correlation Index?

This index is useful means of classifying oils on a qualitative basis. The CI value is calculated by the formula: **CI = 48640 / K + 473G – 456.8** where K: average boiling point of the fraction (Kelvin), G: Specific gravity of the fraction at 60”F. **Note,** The lower the CI value, the greater the concentration of paramn hydrocarbons in the fraction, the higher the CI value, the greater the concentration of naphthenic and aromatic hydrocarbons.

69 What is A Hydrometer?

Is an instrument used to measure the specific gravity (or relative density) of liquids; that is, the ratio of the density of the liquid to the density of water

70 Define Gasoline and Kerosene?

Gasoline is composed of hydrocarbons ranging from C_5 to C_{10}- The cracking process in the refineries was developed to produce gasoline-sized molecules from higher-order hydrocarbons. Polymerization of smaller compounds also gives gasoline molecules. Combined, these two processes can produce up to 70% gasoline from crude oil.

Kerosene- The next highest group is kerosene, with molecules ranging from C_{11} toC_{13}- It is the first fraction that shows a significant amount of cyclic hydrocarbons (10-40% aromatics, also naphthene's). Kerosene replaced whale oil for use in lamps. Its production can also be increased by cracking during the refining process.

71 What is a Flash point?

Determines below which temperature oil can be handled safely " without its fumes being spontaneously ignited"- For kerosene, the flash point is considerably higher than for gasoline. This, together with its relatively low freezing point is a main reason for its use as airplane fuel

72 What is Viscosity of Hydrocarbon?

It is an inverse measure of the ability of a substance to flow, The greater the viscosity of a fluid, the less freely it flows. Crude oils vary greatly in viscosity. Some, such as natural gas and light oils are very mobile others are highly viscous and these grade into the semisolid petroleum - Viscosities vary directly with the composition: The greater the number of carbon atoms in a member of a hydrocarbon series, the greater will be its viscosity

73 What are Electrical properties of oils?

Oils are dielectric, so the electrical methods are using for discovering oil-bearing beds in the well. The wire line is spooled out the back the truck, over a pulley, and down into the hole. There are many kinds of electric logs.

74 What is the Origin of Petroleum from geologic point of view?

1. All hydrocarbons occur in sediments of marine and continental origin.
2. Petroleum is extremely complex mixture of many hydrocarbons. No two crudes are similar; however, the elemental chemical analyses are similar.
3. Petroleum is found in rocks from the Precambrian to the Pleistocene, although the occurrences in some aged are anomalous
4. Until the advent of chromatographic and similar tools, no bitumen had been found in shales and carbonates. “Source Rocks” insoluble organic matter (kerogen) was found in the sediments
5. The temperatures of petroleum reservoirs range from 107 – 150°C in some deeper reservoirs.
6. The origin of petroleum is within an anaerobic and reducing environment. The presence of porphyrins means anaerobic conditions developed early in life of petroleum.
7. No diNerences have been observed between oil pools formed due to migration and that have not a Nected by migration.

75 What is the most important progenitor of petroleum?

Lipids may be the most important progenitors of petroleum. The lipids content of all forms of organic matter is more than enough to account for the origin of petroleum. It is shown that less than 1% of the organic matter in sediments is required to form all the known petroleum.- Lipids are more resistant to degradation in reducing environments than proteins and carbohydrates. Note: most of petroleum formed in catagenesis stage.

76 What are Elements and processes of petroleum system?

The essential elements of a petroleum system include the following:
1. Source rock.
2. Reservoir rock.
3. Seal rock.
4. Overburden rock.

Petroleum Systems have two processes: 1. Trap formation 2. Generation-migration- accumulation of hydrocarbon

77 Which type of geological folds is the best for petroleum accumulation?

The dominant structural features are salt domes and down-to-the-Coast growth faults, all normal faulting. Large petroleum accumulations are trapped on salt domes, in downthrown 3-way fault traps, four-way closures (anticlines), and stratigraphic traps.

78 What geologic situations is most likely to contain significant oil deposits?

Petroleum trap: underground rock formation that blocks the movement of petroleum and causes it to accumulate in a reservoir that can be exploited. The oil is accompanied always by water and often by natural gas; all are confined in a porous and permeable reservoir rock, which is usually composed of sedimentary rock such as sandstones, arkoses, and fissured limestones and dolomites.

79 Where is petroleum found around the world?

Petroleum is found in 'reservoirs' in the subsurface. Reservoirs contain economic accumulations of petroleum. In the past economic reservoirs were restricted to rocks of suitably high permeability that petroleum could be produced at economic rates. Now, with the advent of large scale hydraulic fracturing, commercial production rates can be attained even in very low permeability rocks, assuming there's a high enough concentration of petroleum present.

80 What are fundamental requirements for commercial petroleum reservoirs to form?

A **source rock**, containing a high enough concentration of primary sedimentary organic matter to form significant amount of petroleum during burial. Most source rocks are comprised of shale or siltstone, although some are carbonates. A **reservoir rock**, having sufficient volume and high enough porosity and permeability to support commercial production. Most conventional reservoir rocks are sandstone or carbonate (limestone or dolomite) (Carbonate reservoirs must be naturally fractured or partly dissolved to create the required porosity and permeability). A "**seal**", which is a low permeability barrier that traps petroleum in the reservoir. Seals are typically formed by low perm strata, such as shale, or sometimes by faults. And finally, **Burial history** and heating, that will "cook" the source rock to cause petroleum to form from the primary OM, and migrate to the reservoir, where it will accumulate.

81	Which geological fold is more beneficial to extract production?

Anticline Traps. If a permeable reservoir rocks like a sandstone or limestone is sandwiched between impermeable rock layers like shales or mudstones, and the rocks are folded into an anticline, petroleum can migrate upward in the permeable reservoir rocks, and will occur in the hinge region of the anticline.

82	What is the difference between “fracking” and conventional oil extraction methods?

Within the framework of your question the two overlap almost completely. Well over 90% of conventional wells received at least one hydraulic fracturing process. It’s been a long time since spindle top and those reservoirs are not all that numerous. Almost every formation penetrated today and in every year since the first frac job in 1949 has improved performance due to hydraulic fracturing. IOW hydraulic fracturing is a conventional operation.

83 What is the difference between shale oil and crude oil?

The main difference between crude oil and shale oil is the process of generation of each type of oil. First, let us understand more about shale rock.

Shale rock is a fine-grained, soft sedimentary rock which is made up of clay particles and other minerals such as calcite and quartz. The clay particles are extremely small in size (less than 1/64 mm), which gives the shale it's fine texture.

Crude oil is generated in shale rock, when the organic matter in the rock is exposed to high temperature and pressure over a period of several million years. However, this crude oil attempts to reach to the surface, and it migrates from the shale rock to other rocks like sandstone and limestone, which act as reservoir rocks and provide spaces for the crude oil to accumulate. Crude oil may also be found in shale rock areas because the oil has not been able to migrate (several factors influence this).

Shale oil, on the other hand, is generated by processing the organic matter present in the shale rock. Processes like pyrolysis (heating in absence of oxygen), hydrogenation (addition of hydrogen to shale rock and reacting it) or thermal dissolution are used to extract oil from shale rock. The oil produced is synthetic and can be used for the same purposes as conventional crude oil.

84 Petroleum deposits are mostly confined to the coastal regions why?

It's because the vast majority of the world's petroleum originated as plankton growing in shallow seas, which died and was buried in mud under anaerobic conditions where it could not be consumed by other organisms. Over the eons it was buried deeper and deeper, up to several miles deep, and the pressure and heat of overlying formations compressed the mud into shale and the plankton embedded in it into oil. Once the oil was created from the dead plankton remains, it became a fluid, so it often migrated up through the rock into other formations. The vast majority (99%) escaped to the surface and was destroyed by bacteria and oxidation, but the amount that was captured in oil reservoirs is still quite considerable since this process has been going on for over 500 million years.

85 **Is petroleum found only under the ocean?**

Not at all. Most of the US production historically has been (and is) from land based drilling operations. Drilling only moved out to sea-based platforms because land sources declined or were already exploited.

86 **Before the discovery of geophysics how did geologists point out the hidden hydrocarbons in the subsurface?**

Petroleum exploration was made possible by the understanding in the 19th Century of oil traps created by the crustal deformation of stratigraphy. Certain combinations of rock formations and deformations formed reservoirs of oil. Geologists could map structures on the surface and infer their continuation below the surface. The target was very general and drilling for oil in prospect areas was a hit or miss affair.

87 **Define Oil Well?**

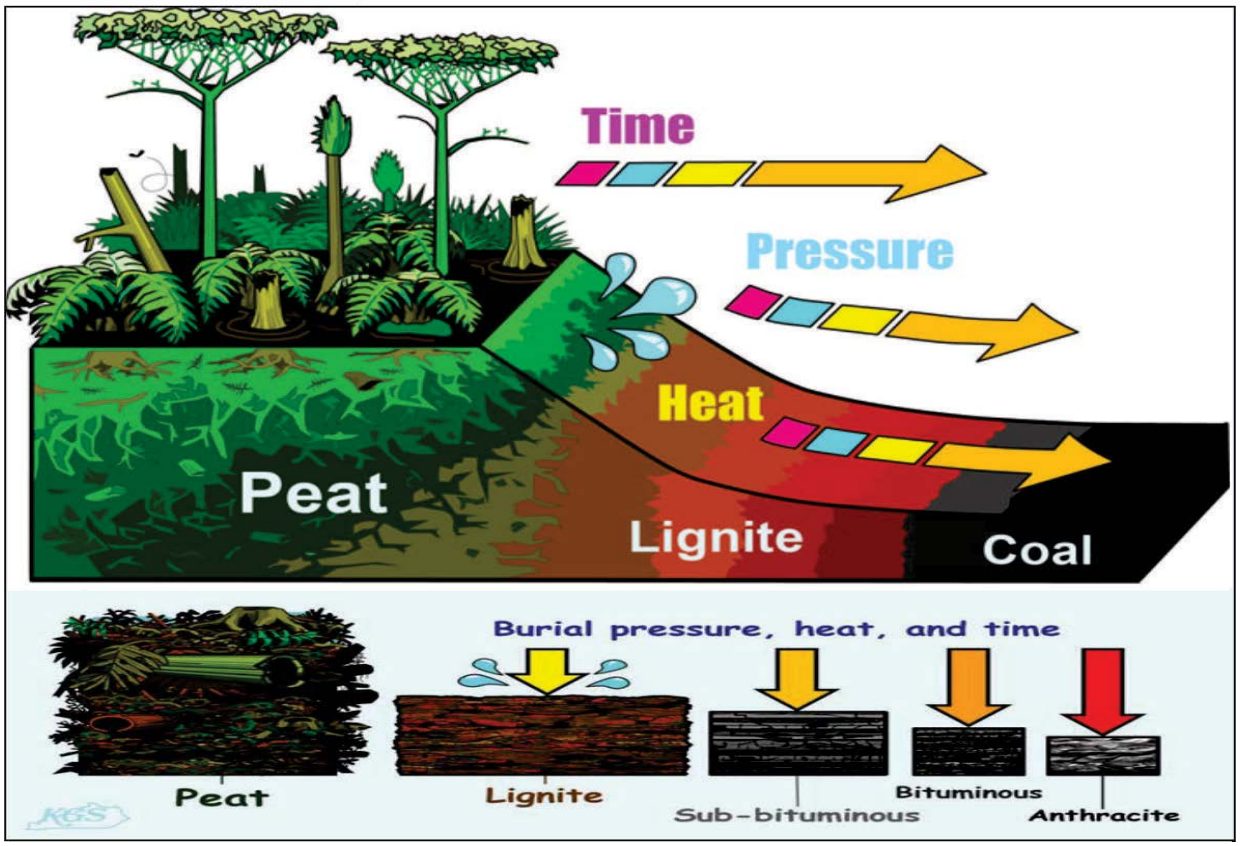
An **oil well** is where the oil comes to the surface of the ground. Sometimes this oil "wells" up all by itself, as in tar swamps, but more commonly the oil needs to be pumped up through a bored hole. The term is now applied generically to all the places where oil is recovered, pumped or not.

88 **What is the kerogen formation?**

The naturally occurring, solid, insoluble organic matter that occurs in source rocks and can yield oil upon heating. Kerogen is the portion of naturally occurring organic matter that is non extractable using organic solvents. Typical organic constituents of kerogen are algae and woody plant material. Kerogens have a high molecular weight relative to bitumen, or soluble organic matter.

89 **How the Coal is formed and what kind of coal Most likely to be found in strata that were deeply buried, but not folded ?**

Coal was formed millions of years ago. When the earth was covered with swamps and bogs, there were very warm and wet conditions. Plants died in the water, and were eaten by bacteria turning them into a sludge of Peat. Over time, this layer of Peat was covered with many, many layers of soil and rock. The pressure from being buried squeezed out hydrogen, nitrogen and oxygen to leave carbon. Some of the material fell apart completely, some turned brown and doesn't have as much carbon, and some turned black and has a lot of carbon remaining. There are three grades of coal. Bituminous is the mid rank (also known as soft coal) to be found in strata that were deeply buried but not folded.



90	**What is important fossils in identifying oil horizons?**	
	Foraminifera	
91	**What is the temperature window for significant oil generation?**	
	60-120°C	

92	**What is the key reaction for the conversion of the inorganic carbon into organic carbon?**
	Photosynthesis
93	**What are the major chemicals that are found in the organic matter?**
	Proteins, Carbohydrates, Lipids, Lignin
94	**What factors control the preservation of organic matter in the sub-surface?**
	Oxygen-depleted bottom conditions, Rate of sedimentation, Subsurface temperature.
95	**What is an inorganic chemical paleothermometer?**
	Fluid inclusions
96	**What are the secondary pores in a sedimentary rock?**
	Pores that are formed after deposition.

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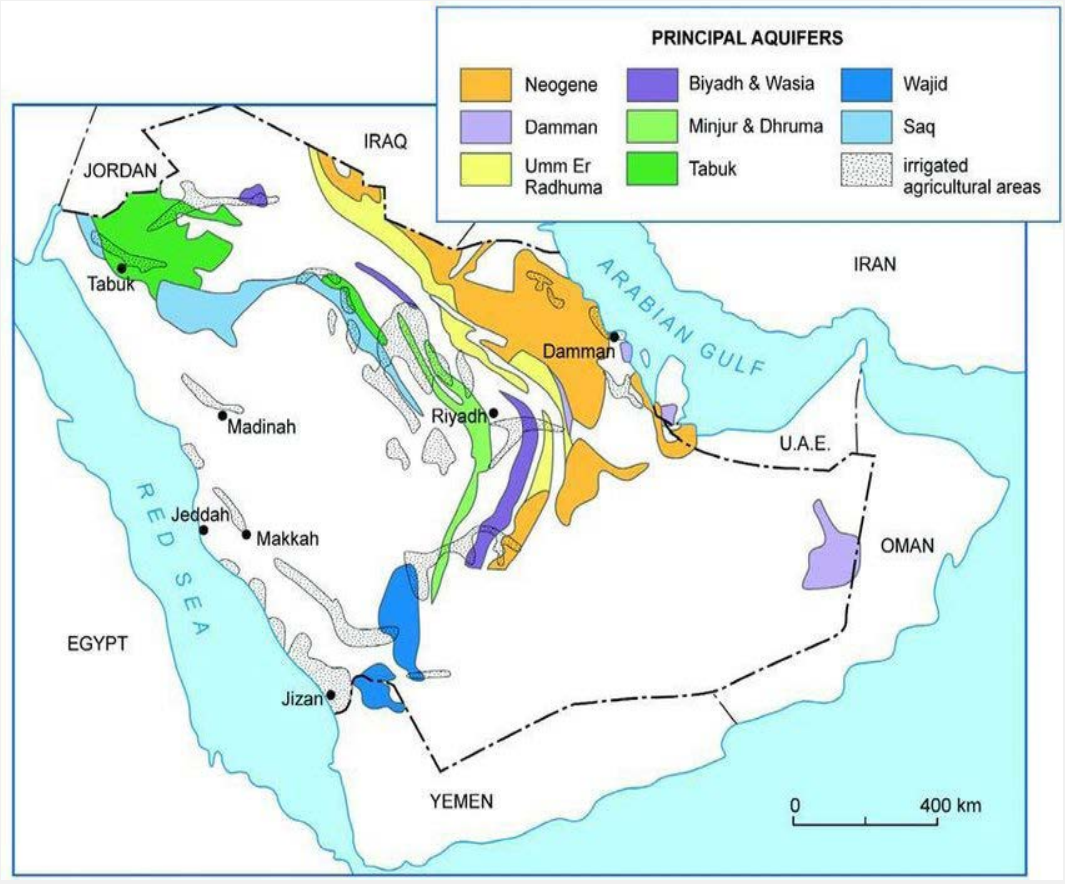
Questions & Answers in Hydrogeology



Hydrogeology

Introduction

Groundwater constitutes 30 per cent of the world's available freshwater. A further 69 per cent is locked up in polar icecaps, while rivers and lakes only represent one per cent. Groundwater is often hidden deep in aquifers, permeable rocks and sediments and is extracted using pumping wells. Often, aquifers can be renewable water resources, slowly replenished by rainfall infiltration over hundreds up to many thousands of years. A successful groundwater management requires precise information on groundwater quantity and quality, its renewability and the hydrogeological structure of the underground. Based on this data, utilization concepts are developed that also consider ecological and socio-economic aspects.

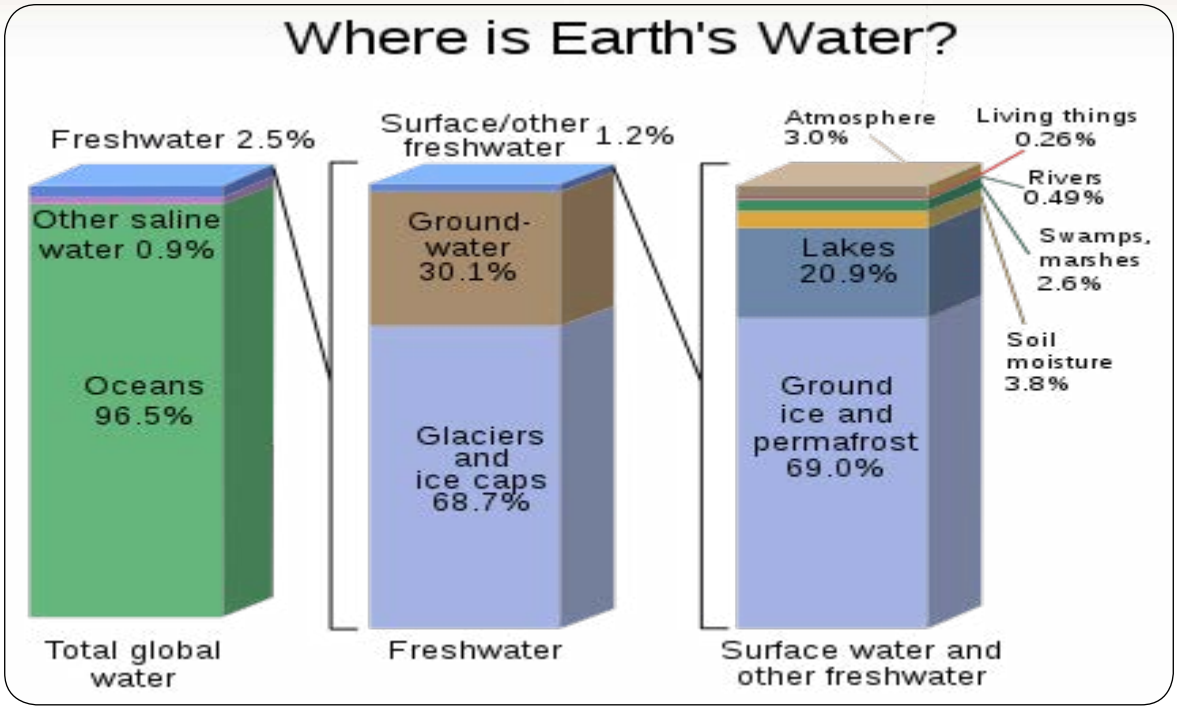
1 What is Hydrology & Hydrogeology?

Hydrologists and hydrogeologists are water scientists who study the properties of freshwater and its distribution on the continents. (Oceanographers study the physical and chemical properties of salt water in the oceans.). Together, hydrology and hydrogeology provide information on how to manage and protect freshwater, humans most essential natural resource. **Hydrology and hydrogeology** are distinct fields of study that employ different methods and techniques, but they overlap to provide a complete picture of Earth's freshwater resources.

Hydrology is a branch of engineering that deals with the physical properties of surface freshwater, such as lakes and rivers, and with its chemical interactions with other substances. **Hydrogeology** is a subfield of geology (study of Earth) that, by definition, specifically addresses groundwater—water moving through tiny openings in rock and soil layers beneath the land surface. In practice, ground and surface water interact as a single system. Surface water seeps into the ground and groundwater emerges to the surface. Hydrogeologists work to explain the geological effects of surface water in rivers, streams and lakes, and hydrologists lend their technical expertise to the mechanics and chemistry of moving groundwater.

2 Where is the Earth's Water?

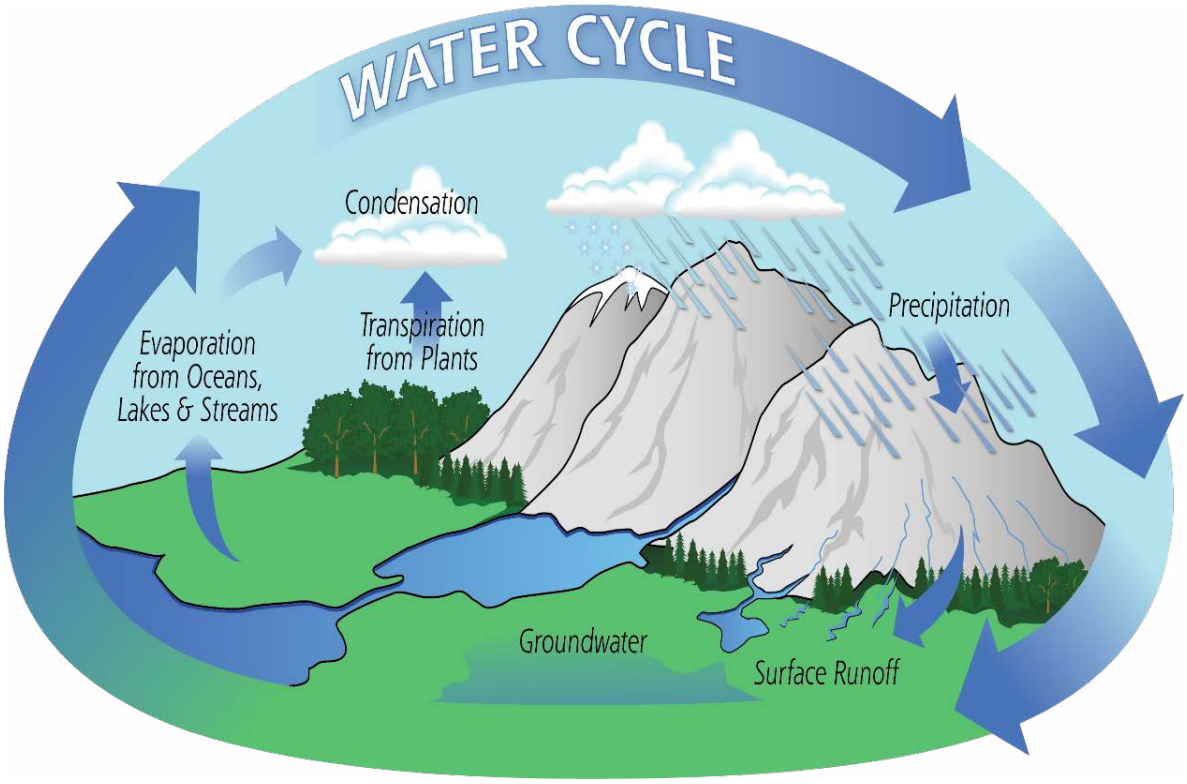
98% of it is in the oceans. The little blue square on top of that column is "fresh water:, whose distribution is shown in the second column. Likewise the thin blue square on top of that column is expanded to the 3rd column, which is the (mostly) surface fresh water.



3 **Explain every step of the water cycle.**

Approximately 75% of Earth is covered by water, in the form of lakes and oceans, or ice. The water cycle, also known as the hydrologic cycle, describes how water continuously moves through Earth and the atmosphere. Throughout the cycle, water changes to be in the form of gas vapor, liquid, or solid ice. The water cycle has a large impact on the environment and ecosystems and is vital for life. The cycle also is a part of the overall system of weather.

The main steps in the water cycle include precipitation, runoff water, precipitation and transpiration, and condensation. When water is heated by the sun or by other factors, surface water evaporates and changes from liquid to vapor state. Similarly, transpiration is the evaporation/release of water from plants. Sublimation is the process of ice turning to vapor directly, without changing to a liquid state first. As water vapor rises to the atmosphere, it cools and begins to condense into clouds. Precipitation occurs when water falls from clouds, in the form of rain, snow, ice, etc. The liquid form eventually drains into oceans, lakes, and streams. It also gets absorbed into the soil, where it will move underground until it reaches a body of water, gets taken up by a plant or an animal, and/or it evaporates again.



4	**An aquifer is a body of permeable rock or sediment through which groundwater moves. In an artesian well or spring, water rises above the aquifer that feeds it. What geological conditions are required for such a situation to occur ?**	
	An artesian system can exist when an inclined aquifer is sandwiched between impermeable layers. If the level of the water table in the aquifer is sufficiently high, water will be forced to the surface either through a fissure in the upper impermeable layer to form an artesian spring or through a well dug down to the aquifer.	

5 What is "hard" water ? How can it be made "soft" ?

"**Hard" water** contains dissolved minerals which prevent soap from forming suds, react with soap to produce a precipitate, and form insoluble deposits in boilers. Calcium and magnesium ions are usually responsible for hard water. Groundwater often contains these ions through the solvent action of water containing dissolved CO_2 on rocks such as limestone.
To soften water, the Ca^{++} and Mg^{++} ions must be removed, which can be done in a variety of ways. In one common method, hard water is passed through a column containing a mineral called zeolite, which absorbs Ca^{++} and Mg^{++} ions into its structure while releasing an equivalent number of Na^{++} Ions. Since Na^{+} ions do not affect soap, nor do sodium compounds precipitate out from hot water, the water is now soft.

6 Where does the water come from that feeds a spring ?

A **spring** is fed by groundwater that reaches the surface in a more or less definite channel. The groundwater itself was originally rainwater.

7 Why are mineral deposits near hot springs thicker than those near ordinary springs ?

Minerals are more soluble in hot water than in cold water, hence the mineral content of water from a hot spring is greater than that of water from a cold spring.

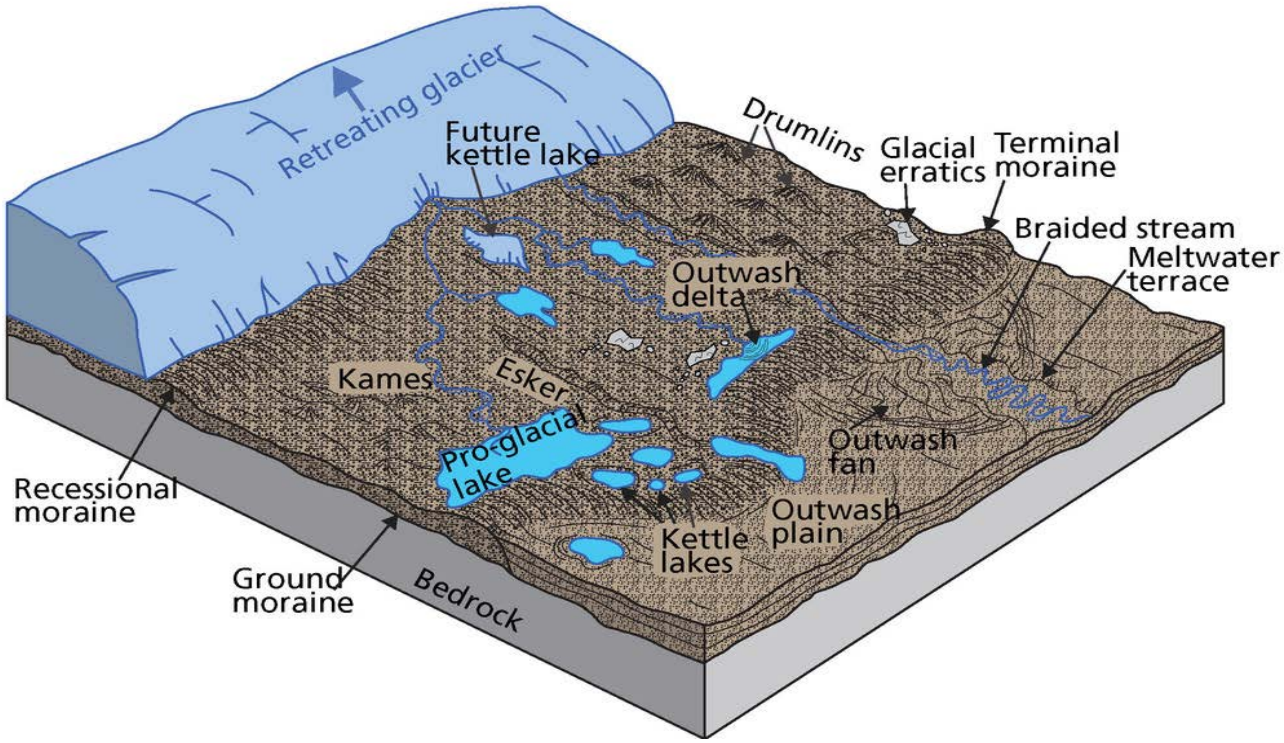
8 **Distinguish between the laminar and turbulent flow of a stream. Which is more effective in transporting sediments ?**

In **laminar** (or "streamline") flow, each particle of water passing a particular point follows the same path as the particles that passed that point before. The direction in which the individual particles move is the same as that in which the stream as a whole is moving. In turbulent flow, the water motion is irregular. Successive water particles passing the same point do not in general follow the same paths, and in places they move opposite to the direction in which the stream as a whole is moving. Eddies and whirlpools are characteristic of turbulent flow.

Turbulence occurs when the stream velocity is high, when the stream bed is rough, and when there are obstructions or sharp bends; mountain streams commonly exhibit turbulent flow. Sediments have a greater tendency to remain suspended in a turbulent stream, hence such a stream is more effective in transporting them.

9 **Glaciers are observed to wear down bedrock that is harder than glacial ice. How can this happen ?**

Embedded in glaciers are stones and boulders, some of which are hard enough to erode the bedrock.



10	**What agent of erosion produces valleys with a V-shaped cross section? A U-shaped cross section ?**	
	Streams; glaciers.	

11	**Can springs have cool or warm water?**	
	Both. Some springs have cool water and some have hot water. If water flows deep in the Earth, the water becomes heated.	

12	**What is the gaseous form of water?**
	Water Vapor

13	**What percentage of fresh water is in the form of icebergs?**
	75% or Three quarters

14	**Most fresh water in the atmosphere is the in the form of what?**
	Water Vapor

15	**What are the major processes of Water Cycle?**
	Evaporation, Condensation, and Precipitation.

16	**What produces water vapor from plants?**
	Transpiration.

17	**What forms clouds from water vapor?**
	Condensed water droplets that combine with dust particles in the atmosphere.

18	**Precipitation falls back to the earth in what forms?**
	Rain, snow, sleet, and hail.

19	**Why does water vapor condense (condensation) when it travels far above the earth?**
	Higher up, air tends to be colder. Cold air holds less water vapor than warm air. It condenses into liquid water.

20	**How do clouds form?**
	Condensed droplets of water clump together around tiny dust particles forming clouds.
21	**If groundwater reaches the surface, how does it reenter the water cycle?**
	It reenters the water cycle by evaporation into the earth's atmosphere.
22	**What is the source of all fresh water on the earth's atmosphere?**
	Precipitation.
23	**What and how do icebergs form ?**
	Fresh Water. When glaciers reach the sea coast, large chunks break off forming icebergs. They are tracked by using ships, planes, and satellite.

24 **Why is it important to track icebergs?**

To warn ships and other watercraft of icebergs to prevent accidents.

25 **In the water cycle, how does water return to the ground?**

Precipitation. The water cycle is an important aspect of all ecosystems. It involves biotic and abiotic factors, which play a role in the pathways that move water in the water cycle. The water cycle is a recycling process that has no starting point, nor ending point. It can be divided into three stages: gas, liquid, and solid. The evaporation of water from bodies of water, such as an ocean, returns it to the atmosphere. This water, now in the clouds as vapor, can be converted back to liquid, which is known as condensation. The cooling of vapor in the clouds makes precipitation that is returned to the ground as rain, sleet, hail, and snow.

26 **In the water cycle, what happens to water after it evaporates from the ocean?**

It condenses into clouds. The next step of the water cycle after evaporation is condensation, causing the water to form clouds after it leaves the ocean. The clouds are then able to transport the water over land and return it to the soil via precipitation.

27 **Where is most of the water located on Earth?**

Most of the planet's water is located in the oceans as salt water. The earth's surface is about 71% covered by the oceans, and those oceans hold about 96% of all the water on earth.

28 **Which could affect infiltration of water into the surface of the soil?**

Infiltration is the process by which water can seep or be absorbed into the soil, which makes the soil wet or turns the water into groundwater. If there is something covering the soil, like a road or a sidewalk, then the water cannot be absorbed and instead sits on the hard surface. Parks and gardens allow the soil to be exposed and the water cycle to continue.

29 **In the water cycle, where does water go once it has evaporated?**

Evaporation is the process of water moving from the liquid phase to the gaseous phase and rising into the atmosphere. Once water has evaporated, it rises up into the atmosphere where it cools and forms clouds. During precipitation, this water may turn into river, lake, or ground water, which plants may have access to through their roots.

30 **Water loss from plant leaves is called?**

Transpiration. When plants lose water through its leaves, it is called transpiration. This happens when it gets too hot and the water they have stored evaporates and escapes from the stomata of their leaves. Respiration refers to the cellular process by which energy is produced. Perspiration is also known as sweating, and is used to prevent overheating. Precipitation is the falling of water (in one of several forms) from the atmosphere.

31 **How does water enter the atmosphere?**

Evaporation, transpiration and sublimation are the three processes by which water is vaporized and allowed to enter into the atmosphere. Transpiration is the process by which water is lost from plants during photosynthesis and respiration. Evaporation is the process by which water is vaporized by absorbing enough solar energy to break away from the rest of the water molecules, note the body of water does not come to a boil during evaporation. Sublimation is the vaporization of ice into water vapor in much the same way that evaporation occurs.

32 **Which part of the water cycle is a principle agent of erosion?**

Precipitation and **runoff**. Only precipitation and runoff are the only two hydrologic cycle processes from the potential answers that result in major erosion.

33 **How much of world's freshwater is locked up in glacial ice?**

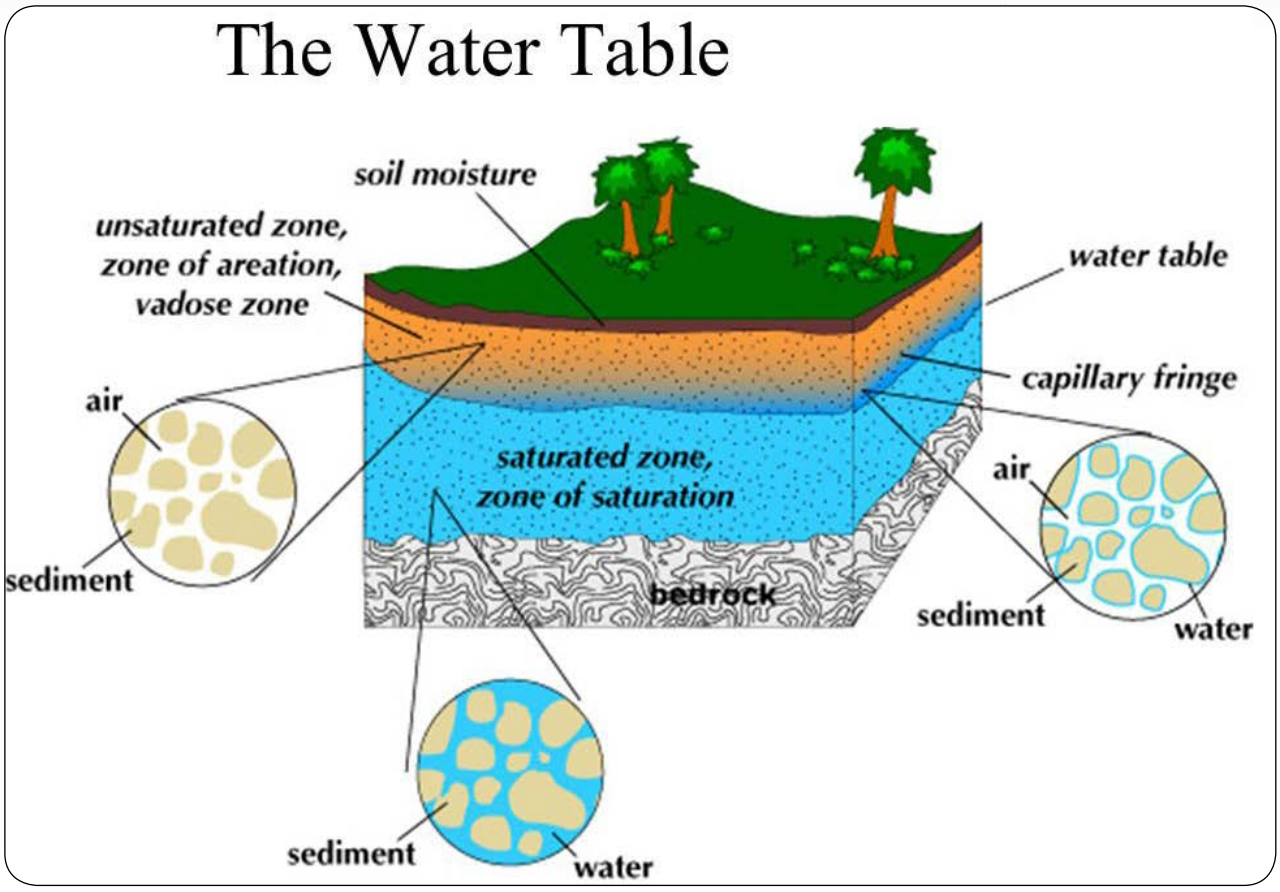
68.7%. The glacial ice of the Arctic and Antarctic along with mountain glacial peaks compose 68.7% of all the freshwater on Earth.

34 Describe Darcy's law in terms of groundwater flow?

Darcy's law is a phenomenologically derived constitutive equation that describes the flow of a fluid through a porous medium. The law was formulated by Henry Darcy based on the results of experiments on the flow of water through beds of sand. It also forms the scientific basis of fluid permeability used in the earth sciences, particularly in hydrogeology. Darcy's law relates the pressure drop and the velocity in an unbounded porous medium. For the flows of a viscous **Newtonian fluid** at low speed through a porous medium, the pressure drop caused by the frictional drag is directly proportional to the velocity.
in 1856, a French hydraulic engineer named **Henry Darcy** published an equation for flow through a porous medium that today bears his name.
$Q = KA (h_1-h_2)/L$ or
$q = Q/A = -K\, dh/dl$, h: hydraulic head, $h = p/rg + z$
$q = Q/A$ is the specific discharge [L/T],
dh/dl is the hydraulic gradient
K is the hydraulic conductivity **[L/T]**

35 Define the following groundwater terms?

An aquifer is a saturated geological formation that contains and transmits "significant" quantities of water under normal field conditions (=> gravel, sand, volcanic and igneous rocks, limestone).
An aquiclude is a formation that may contain water but does not transmit significant quantities (clays and shales).
an aquitard is a formation with relatively low permeability.
confined and unconfined (water-table) aquifers. An unconfined aquifer has a water table (water table aquifer). A confined aquifer does not have a water table. If you drill a well, water will rise (in the well) above the top of the aquifer.
perched groundwater is groundwater sitting on top of a poorly permeable layer with an unconfined aquifer underneath.
The height to which water rises in a well defines is known as the **piezometric or potentiometric surface**.



36 Show examples the geology of aquifers?

- **unconsolidated sediments**: loose granular deposit, particles are not cemented together (e.g.: Long Island)
- consolidated sediments, most important: sandstone, porosity varies depending on the degree of compaction (e.g. Zion, Bryce, and Grand Canyon National Parks)
- limestone: composed mainly of calcium carbonate, CO2 rich water dissolves limestone, e.g.: limestone caves, karst (e.g. Floridan aquifer)
- volcanic rock
- basalt lava, fractures (e.g.: Hawaii, Palisades)
- crystalline rocks: igneous and metamorphic rocks, e.g. Granite, have often very low porosity, flow through fractures
- porosities and hydraulic conductivities of different aquifer rocks

37 What is the chemical name of water ?

Water is made from hydrogen and oxygen, two nonmetals. The first element listed gets a prefix di- since there are two hydrogens in H2O. So the first part of the **name** is dihydrogen. The second (and last element) listed will end in the ending-ide. So since there are no more than one oxygen you will just go with oxide. So it's dihydrogen oxide. In other way is to have the oxide take the prefix mono- cause there is only one oxygen. So the **name** becomes dihydrogen monoxide.

38 How to explore ground water?

Geophysical process like electrical sounding can bring out the exact depth, thickness and extension of wet bodies underground. Once the lay and disposition in mapped you can easily plans about developing the resources by drilling a tube well . but one should always remember that water is a resource and should never be wasted or over exploited.

39 What are the effective ways to recharge ground water?

- Harvesting rain water. All individuals can participate simply by collecting the water in a soaking pit.
- In hilly terrains, the run-off can be blocked and pumped back to up-hill ponds/reservoirs
- Grow trees (e.g. Ficus Elastica) in contoured terrains to slow down run-off and prevent soil erosion that causes rapid run-off.

40 Why is ground water decreasing?

Groundwater is decreasing because of the following reasons

- annual rainfall is reducing due to reduction of forest cover
- due to urbanization much of the soil surface which allow rainwater to percolate into the soil and add to the groundwater is being covered by impervious concrete roads, buildings, etc
- whatever rainfalls on the ground surface is carried away swiftly to drains and subsequently to rivers, because water is not allowed to stagnate on the ground surface to permit percolation
- where irrigation canals are not existent, groundwater is being pumped out to irrigate the land, hence the groundwater table is decreasing.
- with each individual residential complex going in for individual borewells or tube wells, the groundwater is depleting. When the adjacent dweller digs his borewell he goes deeper that his neighbors to ensure that he has adequate water, which further depresses the groundwater table.
- due to global warming the atmospheric temperature is rising and the precipitation is also reducing than what we experienced 50–60 years ago.

41 What does depletion of ground water cause?

Falling water table. The most observable consequence is often that you have to dig deeper to get water out. If there are any wells fed by artesian pressure nearby, those will stop their natural outflow. If there are plants nearby whose root systems depend on a water table that rises as high as their root systems, they will die.

Ground subsidence. If you remove enough subsurface fluid, the ground will fall because the interstices in the ground previously supported by the water are now empty. Aquifer compaction results in the land sinking noticeably.

42 What is ground water exploitation?

Groundwater is water that is below the ground surface and not exposed to the atmosphere like in ponds or lakes. The surface waters in ponds or lakes are contaminated by human activities and not sufficient for agriculture, domestic or industrial use. Hence we tap the water that is stored in the groundwater reservoir. We drill through the ground rock below the top soil and reach the groundwater reservoir from where we pump out water for our needs. As more and more people are drilling borewells to tap the source or water, the groundwater table gets lower and lower. The shallower strata may not yield enough water and the borewell may become dry and supply lesser than what we require. The result is that the next borewell that is being put in the neighborhood, will go deeper than the previous one. Thus we are going deeper and deeper to get to a more permanent source of groundwater. This not only means more pumping effort is required but the upper water bearing layers are also sinking. This is known as groundwater exploitation.

43 What are the main source of total solids in surface, ground and waste water?

Sources of Total Solids are as follows:

- Soil erosion : silt, clay, dissolved minerals
- Agricultural runoff : fertilizers, pesticides, soil erosion
- Urban runoff : road grime, rooftops, parking lots
- Industrial waste : dissolved salts, sewage treatment effluent, particulates
- Organics: microorganisms, decaying plants and animals, gasoline or oil from roads
- construction run off
- logging activities , etc

44 Why surface water is softer than the ground water?

There is a lot of calcium and magnesium minerals in the soil and subsoil, as the rain (which is essentially pure water) percolates into the ground to become ground water some of those calcium and magnesium salts dissolve. This is particularly so in areas where the rocks below the subsoil are chalk and limestone, so much of these rocks dissolve that you can over thousands of years end up with extensive cave systems and underground streams. The water in these caves is extremely hard.

45 How is ground water extracted?

A well is drilled using the desired diameter (depending upon how much is to be extracted), a screen is inserted at the bottom and a pipe is inserted above the screen extending to the top of the well. Then, a pump is placed down into the well with a discharge line at the top. A centrifugal pump is almost always used with either a motor at the top and a shaft extending to the pump at the bottom or a submersible motor and pump at the bottom

46 Why does ice float on water?

Ice floats on water because it is less dense than water. When water freezes into its solid form, its molecules are able to form more stable hydrogen bonds locking them into positions. Because the molecules are not moving, they're not able to form as many hydrogen bonds with other water molecules. This leads to ice water molecules not being as close together as in the case of liquid water, thus reducing its density.

47 How is the water cycle affected by pollution?

Water pollution affects water, carbon, and nitrogen cycles. The water cycle is the cycle of water moving up from the earth, into the atmosphere, and water falling from the atmosphere to earth. The sun provides all of the energy for the water cycle by evaporating water off of treetops and the ocean's surface. Water from inland areas, evaporates in the ground, and finds its way to the ocean, and just becomes run off and travels to the oceans in liquid form. However, when water evaporates, it comes back in the form of precipitation, or rain. But as it falls, it gather pollutants from the air, and becomes acid rain. This further pollutes water and its inhabitants, but water pollution does not solely affect the water cycle. This is mainly because when water evaporates, it leaves behind minerals, and even pollutants, and goes up as "clean" water.

48 Is the water cycle the same as the hydrological cycle?

Water cycle and hydrological cycle are not the same, though they involve the same fluid, water. **In water cycle**, the water goes through molecular transformation from liquid, through evaporation, to gaseous state, i. e. vapor, as it is warm, rises into the atmosphere. It gets condensed as clouds in the atmosphere. It eventually cools enough to fall back as rain, or snow, depending on which part of the world the condensation takes place, and what time of the year.

Hydrological cycle is the movement, storage, and pattern of surface and groundwater on and under the earth. Essentially, here, there is usually no significant molecular transformation of the water into vapor throughout the distribution or storage process; water remains liquid, or at some time, solid such as ice.

49 How do dams affect the hydrological cycle?

Hydrology is the study of water and what effects a dam being built may have on the downstream environment.
Hydraulics is the study of water flowing in closed and open channels. Both hydraulics and hydrology are used in the study of dams and the study of the effects on the environment.
The hydrologic cycle is the study of rainfall events and how they impact the environment. Because the dam holds back water the water acts as a impervious surface it has a runoff coefficient of asphalt or concrete. So if it is a very large body of water compared to the downstream drainage basin flooding events will occur more often.

50 What is the difference between water table and hydraulic head?

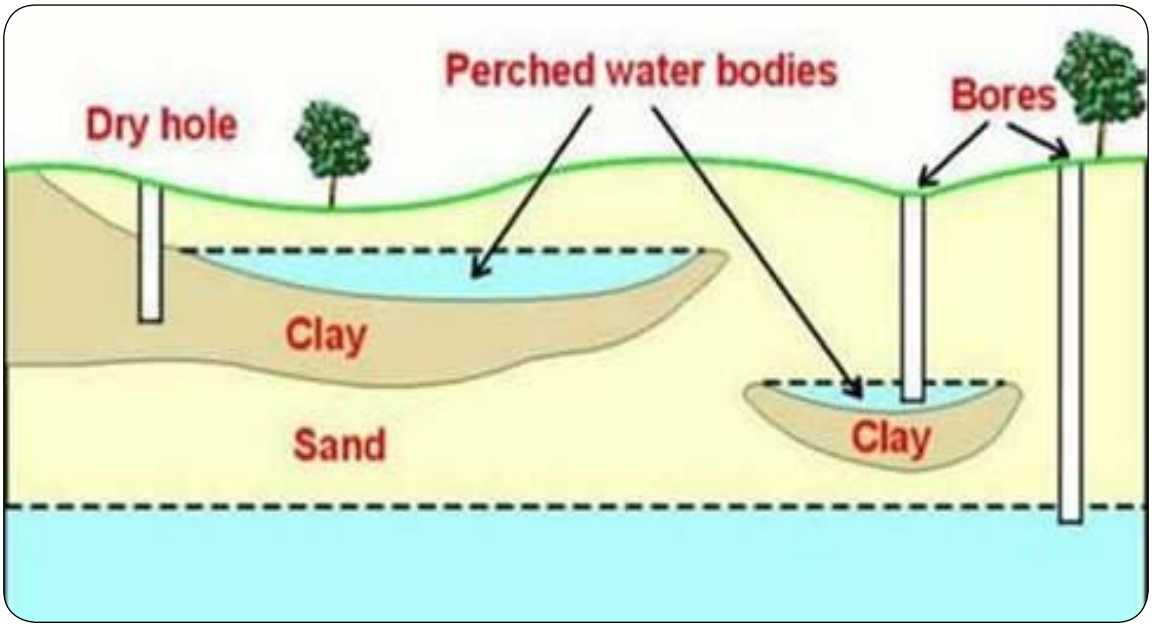
Groundwater table is the depth at which the groundwater actually meets air (unsaturated pores).
The hydraulic head is the potential elevation this water would reach if it were not restricted by some semi-impermeable layer of e.g. clay. In other words: the level + pressure head. So in case of phreatic groundwater the two are equal since it is not under pressure, but in case of confined groundwater the hydraulic head will exceed the groundwater level.

51 Which computer programs are used in hydrogeology?

Most used: **Modflow**. It's a program that simulates sub-surface flow of water. The computational engine is open source and there are many graphical pre- and postprocessors available, such as Visual Modflow, GMS and iMod.

52 What is a perched aquifer?

There are different types of aquifers, according to the position of impermeable layer '(viz Confined aquifer, Unconfined aquifer, Semi confined aquifer and Perched aquifer).



A perched aquifer is separated from another water-bearing stratum by an impermeable layer. Since this type of aquifer occurs above the regional (original) water table, in the unsaturated zone, the aquifer is called a perched aquifer. One main difference between perched and unconfined aquifers is their size (a perched aquifer is smaller). In fact, a perched aquifer is a very small, unconfined aquifer that doesn't contain much water and is only recharged by local precipitation.

53 What are types of aquifers?

Three types : confined, unconfined and leaky aquifers. They are defined by the physical properties and cant be known from before, without a pumping test and its analysis.

Unconfined aquifers are those into which water seeps from the ground surface directly above the aquifer.

Confined aquifers are those in which an impermeable dirt/rock layer exists that prevents water from seeping into the aquifer from the ground surface located directly above. Instead, water seeps into confined aquifers from farther away where the impermeable layer doesn›t exist.

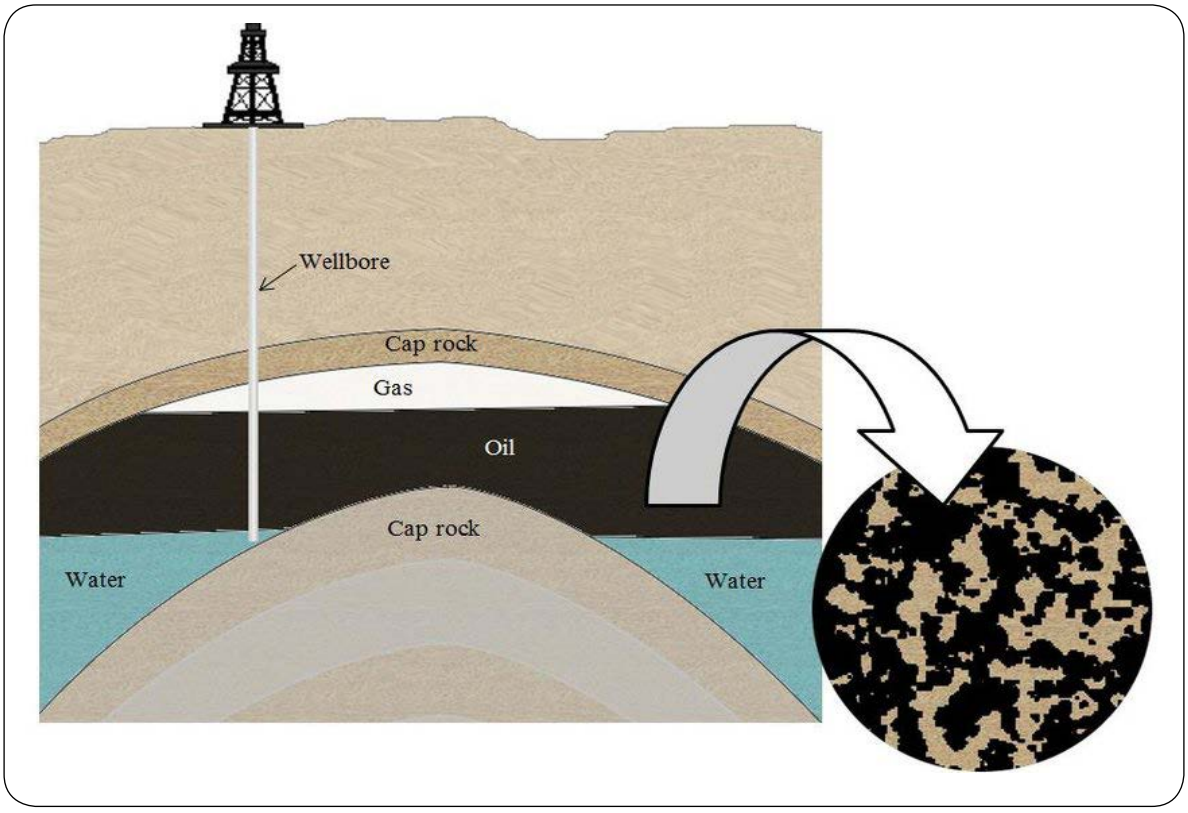
54 What is the difference between zone of saturation and aquifer?

The saturated zone describes ground water from the vantage point of geology and pedology. The aquifer described the same thing from the vantage point of hydrogeology. The aquifer is an underground river for hydrology. Yet this same river is also important for a geologist as he tries to determine how it will develop in the future. For hydrogeology it is more important to know if the aquifer is free or under pressure and if it is saline or not.

Water below the ground surface occurs manly in two zones- zone of aeration (includes soil zone, intermediate zone, capillary zone) and zone of saturation. Water that moves down from the surface is caught by rock and Earth materials and is checked in its downward progress. The zone in which this water is held is known as the zone of aeration. Beneath the zone of aeration, lies the zone of saturation. This is also known as the phreatic zone.

55 What are the differences between reservoir and aquifer?

In geology, "**reservoir**" commonly refers to the porous sedimentary rocks that host fossil fuels, especially liquid hydrocarbons and natural gas (water may also be present but may be very salty rather than drinkable). The fossil fuels originated from elsewhere (an organic-rich source rock) and migrated to the porous reservoir, where they are trapped because the reservoir is often "sealed" by a relatively impermeable overlying rock layer (e.g. salt or clay-rich). **An aquifer** is a saturated geological formation that contains and transmits "significant" quantities of water under normal field conditions.



56 What is the difference between runoff and flood?

Flood is extreme runoff. The basic difference is just quantity. If the run off exceeds the banks of the stream or river, it is a flood. Controlling runoff by creating opportunities for the water to sink down into an aquifer can prevent flooding.

57 What is the difference between surface runoff and baseflow?

Surface runoff is most often associated with overland flow. It is water that reaches a stream quickly and causes it to 'peak' . It is short term response to rain and doesn't last long before infiltrating into the ground. It is the water you see flowing after a rain storm both as a sheet of water over the ground and as small water streams (rivulets), and streams/creeks.

Baseflow is typically sub-surface flow and groundwater discharge that creates the constant flow of water over a longer period of time. It is a slower release of water from the landscape and causes a stream/river to flow long after the rain has stopped.

58 What are the parameters used in water quality testing?

Water quality parameters are broadly classified into three categories i.e., physical, chemical and biological. **Physical parameters** include total solids, col or, taste, odor and temperature. **Chemical parameters** includes pH, hardness, chloride content, nitrogen content, fluoride, alkalinity, and few heavy metals including heavy metal also like iron, manganese, lead, arsenic and mercury etc. **And biological process** we determine pathogens basically by various methods.

59 How do we measure water quality for comparisons?

According to the **EPA, PH, TDS,** hardness, suspended solids, odors, and fluoride that are believed to be the only measurements of water quality are among the 15 secondary parameters. They are auxiliary to the primary ones, and are considered as “nuisance impurities.”

60 What is the Acidity?

Acidity of water is its quantitative capacity to react with a strong base to a designated **PH**. Acidity is a measure of an aggregate property of water and can be interpreted in terms of specific substances only when the chemical composition of the sample is known.

61 What is the Alkalinity?

Alkalinity or the buffering capacity of a stream refers to how well it can neutralize acidic pollution and resist changes in pH. Alkalinity measures the amount of alkaline compounds in the water, such as carbonates, bicarbonates and hydroxides. These compounds are natural buffers that can remove excess hydrogen, or H+, ions .

62 What is the BOD?

Biological Oxygen Demand, or **BOD**, is the amount of oxygen consumed by bacteria in the decomposition of organic material. It also includes the oxygen required for the oxidation of various chemical in the water, such as sulfides, ferrous iron and ammonia. While a dissolved oxygen test tells you how much oxygen is available, a **BOD** test tells you how much oxygen is being consumed.

63 Define Hydraulic Conductivity?

Conductivity is a measure of how well water can pass an electrical current. It is an indirect measure of the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron and aluminum. The presence of these substances increases the conductivity of a body of water. Organic substances like oil, alcohol, and sugar do not conduct electricity very well, and thus have a low conductivity in water.

64 What is meant by Water Hardness?

Hardness is frequently used as an assessment of the quality of water supplies. The hardness of a water is governed by the content of calcium and magnesium salts (temporary hardness), largely combined with bicarbonate and carbonate and with sulfates, chlorides, and other anions of mineral acids (permanent hardness).

65 What is the difference between a natural spring and an artesian well?

Water from an artesian well flows upward with a natural pressure without the need for pumping. The source of water in an artesian well is from a higher elevation than the head of the well. Fossil water aquifers can also be artesian if they are under pressure from surrounding rocks. This is similar to how many newly tapped oil wells are pressurized.

66 What is the difference between artesian spring and gravity spring?

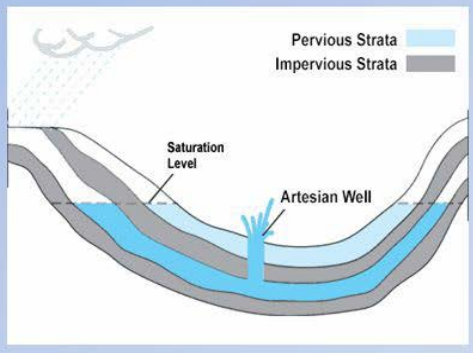
Artesian spring arises out of water flowing below the ground level trying to escape through the soft surface, being pressured by hard surface, like rock. The rain water falling on Earth gets absorbed by the earth and starts flowing as a spring naturally, when the water so fallen is substantial and flows as a stream and may face obstruction in the form of rocks. Pressure therefore builds up and water tries to even come out through soft earth surface, if available. This is the underlying concept of digging open wells. **The gravity spring** is the normal resulting out of difference in flow level.

- DIFFERENT TYPES OF SPRINGS:

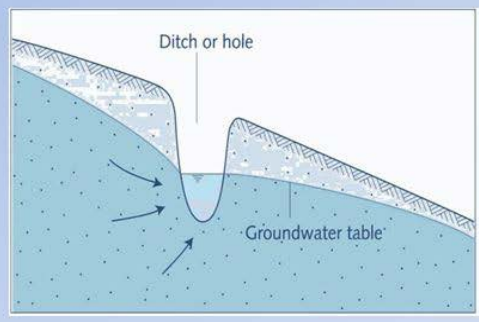
I. ARTESIAN SPRING

II. GRAVITY SPRINGS

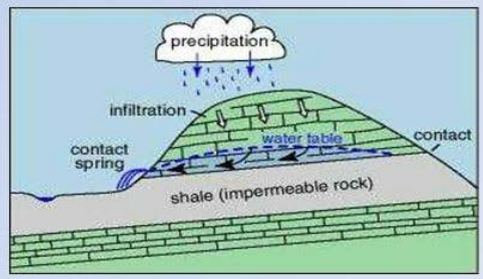
III. SURFACE SPRING



ARTESIAN SPRING



GRAVITY SPRING



SURFACE SPRING

67 **What are the most common examples of environmental hazards?**

1. Air pollution
2. Overpopulation
3. Over-grazing of land or monocultures (not rotating crops and letting land lie fallow).
4. Covering up land with concrete.
5. Noise pollution 6. Light pollution.

68 What is the difference between natural and environmental hazard?

They're very much the same. The environment is our natural world. Tsunami, earthquakes, volcanic eruptions, flash floods, hurricanes and tornadoes are all natural hazards that occur in the environment. Toxic waste spills, oil spills, and man made air and water pollution in general are non-natural hazards to the environment.

69 What is the chemical composition of saline water?

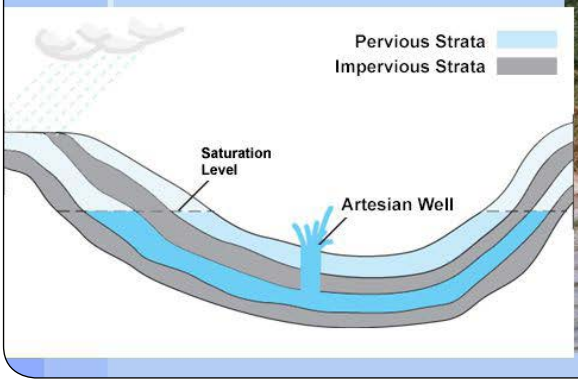
Saline water (more commonly known as salt water) is water that contains a high concentration of dissolved salts (mainly sodium chloride). The salt concentration is usually expressed in parts per thousand (permille, ‰) or parts per million (ppm). The United States Geological Survey classifies saline water in three salinity categories. Salt concentration in slightly saline water is around 1,000 to 3,000 ppm (0.1–0.3%), in moderately saline water 3,000 to 10,000 ppm (0.3–1%) and in highly saline water 10,000 to 35,000 ppm (1–3.5%).

70 What is an Artesian well?

Artesian well, well from which **water** flows under natural pressure without pumping. It is dug or drilled wherever a gently dipping, **permeable** rock layer (such as **sandstone**) receives water along its outcrop at a level higher than the level of the surface of the ground at the well site. At the outcrop the water moves down into the **aquifer** (water-bearing layer) but is prevented from leaving it, by impermeable rock layers (such as **shale**) above and below it

Artesian Wells

- Work just like an artesian spring.
- Since the well head is below the water table, water pressure forces the water up out of the well.
- So you don't need to pump the water out, it comes to you.



71 **What is the difference between surface water and groundwater?**

Surface water occurs on the ground surface in rivers, creeks, lakes, wetlands etc. **Groundwater** is present beneath the ground surface, where it has accumulated within porous or fractured aquifers due to infiltration from the ground surface.

72 What is an aquitard?

An **aquitard** is any material which does not permit groundwater to flow through it in any 'significant' quantity, usually due to a low permeability and/ or thickness (e.g. clay, shale etc).

73 What is an aquifer?

An aquifer is a geologic unit that can store and transmit a sufficient amount of water to supply a well. The factors that determine if a geologic unit is an aquifer include the following: 1. The permeability must be high enough that flow can be maintained. 2. The aquifer dimensions must be great enough (i.e., there must be a significant saturated thickness) to supply water to a well 3. The quality of the water must be good enough for the intended use.

74 How are aquifers recharged?

Aquifers are recharged through rainfall, surface water or river flow and infiltration, or artificially by reinjection to bores or infiltration through ponds.

75 Where does artesian water come from?

Incidental rainfall occurring over a surface area which is able to infiltrate to an underlying aquifer is called a recharge zone. At distance from the recharge zone the aquifer may become confined due to overlying low permeability formations. Artesian conditions, where the confined water is under pressure develops due to the difference in elevation between the aquifer and the recharge zone. If the pressure head within the aquifer is higher than the ground elevation, then groundwater will flow to the surface.

76 How does water accumulate beneath the ground surface?

Incidental rainfall may run-off (to surface water courses/ drains etc) or be lost by evaporation/ transpiration (consumed by vegetation), or may infiltrate the ground surface through seepage via pores (e.g. sand), solution cavities (e.g. limestone) or fractures (e.g. basalt). Water seepage passes through the un-saturated (vadose) zone to reach the water table (saturated zone) as recharge water, which may develop within an aquifer formation. A surface area which conveys water to an aquifer is called a recharge zone.

77 How does groundwater become contaminated?

In a variety of ways, for instance by spillage or leakage of contaminants on the ground surface infiltrating to the water table, by leaking underground tanks or pipes, by rainwater leaching through waste or chemical fill, effluent disposal, leachate from landfill sites etc.

78 What are the factors which influence the discharge of contaminants to groundwater?

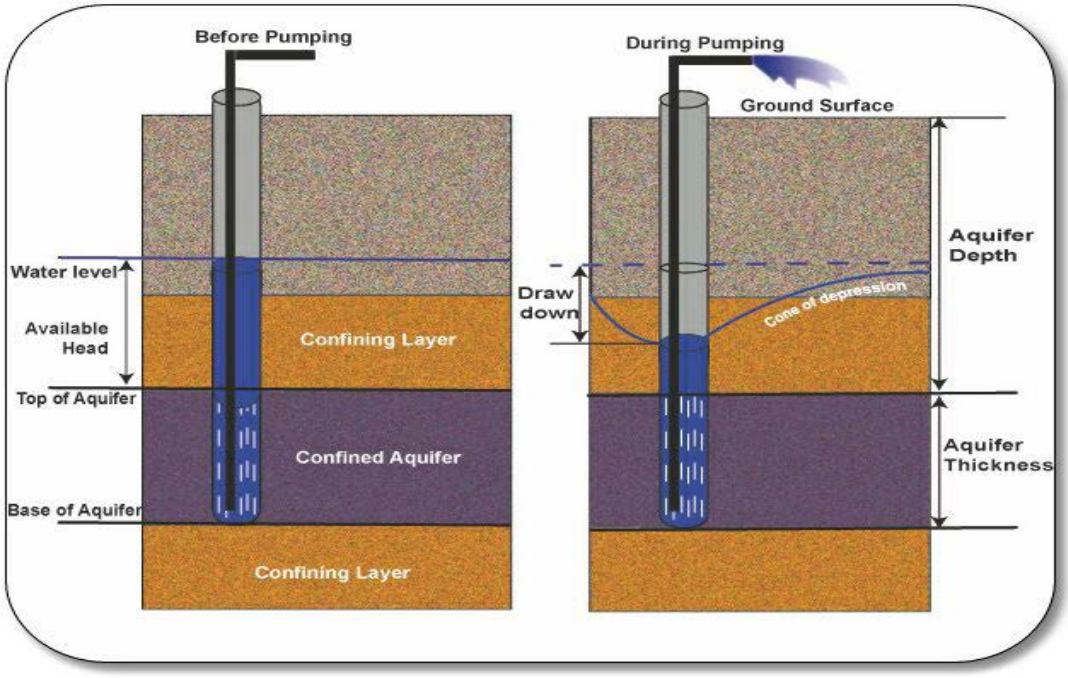
Several factors influence the discharge of contaminated water to groundwater such as the depth to groundwater, the direction of groundwater flow, the type of soil, the flow rate of contaminated groundwater etc.

79 What is aquifer storage and recovery (ASR)?

ASR is the artificial recharge of groundwater via re-injection in bores or re-infiltration from e.g. a lagoon, with the intention of recovering the water at a later time by abstraction. It allows excess or treated water to be stored during plentiful times (e.g. during the 'wet'), for subsequent re-abstraction during dry or high demand periods.

80 What is a pumping test?

A controlled abstraction from a bore, measuring the lowering of the water table over time, can be interpreted to provide hydraulic parameters for the aquifer, including permeability, transmissivity and storativity, and hence assess the sustainable yield of the bore.

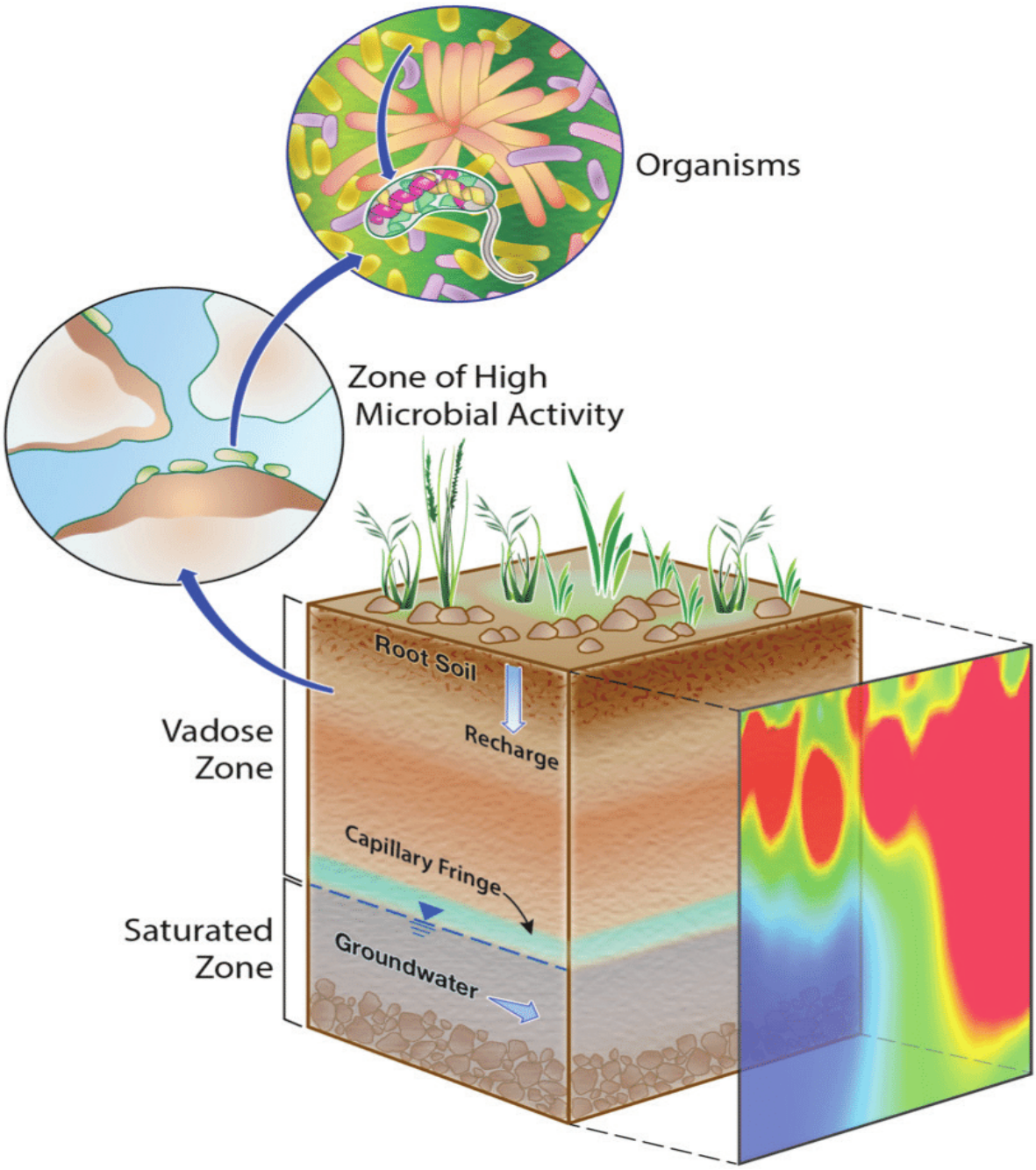


81 WHAT IS POTABLE WATER?

Water that is fit to drink, as a minimum fresh water (i.e. Total Dissolved Solids (**TDS**) <1,000mg/L). However, the Department of Health advises that untreated (raw) groundwater or surface water should not be drunk, since it may contain natural bacteria or chemicals at undesirable concentrations.

82 What is Capillary fringe?

Capillary fringe is the boundary between the water table and the unsaturated zone. It has all the pore spaces full of water, but you could not draw water from a well at that depth .Reason:
the surface tension associated with the grain boundary holds the water by the grain, at less than atmospheric pressure– This zone can be about 5 cm in sand and about 1 meter in silt (higher surface tension effects)


Organisms
Zone of High
Microbial Activity
Root Soil
Recharge
Vadose
Zone
Capillary Fringe
Saturated
Zone
Groundwater

83 How is ground water abstracted?

Deep bores are drilled into deeper aquifers or shallow bores are drilled to unconfined/sandy aquifers. Groundwater is then pumped to the surface for collection, treatment and/or distribution.

84 What are types of interaction between groundwater and surface water body?

- Effluent flow,
- Influent flow and
- Normal flow.

85 What is the difference between Porosity and Permeability ?

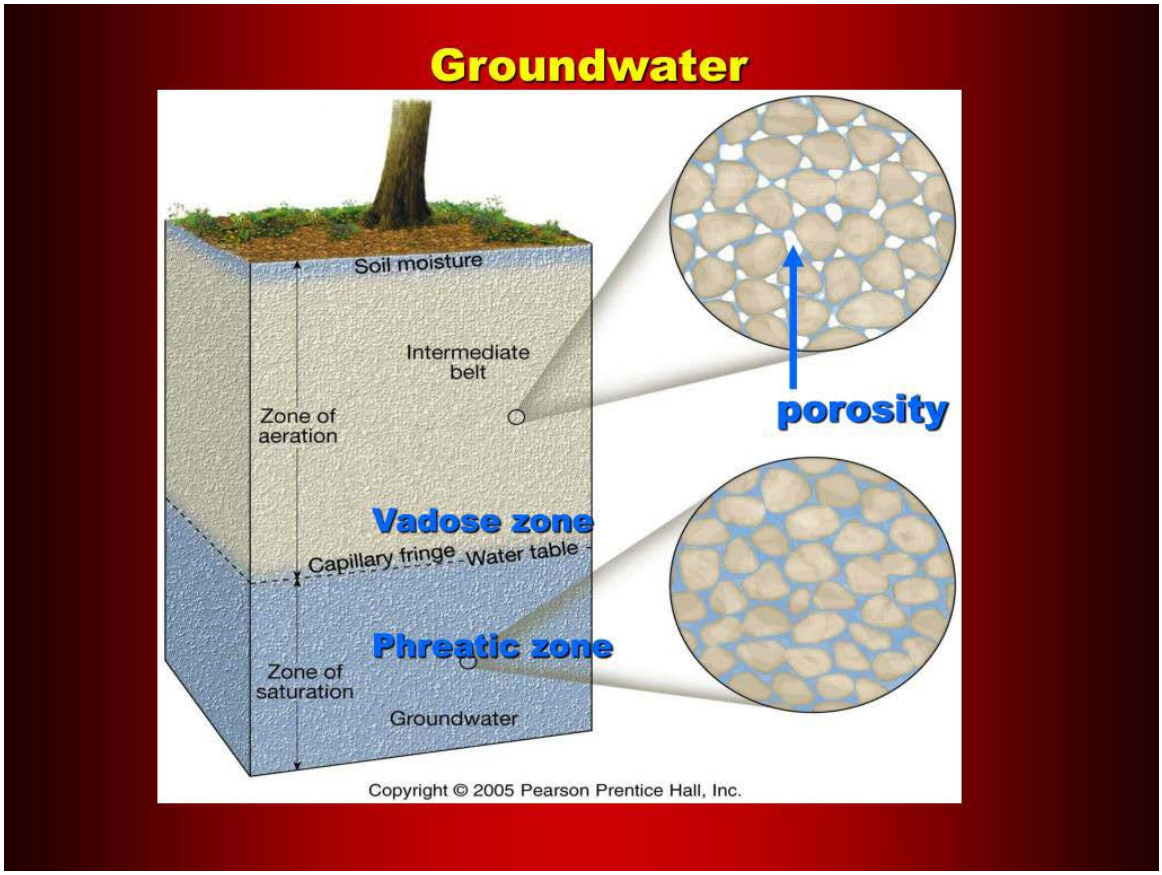
Porosity – Percentage volume occupied by voids. Porosity is independent of scale. For example, a pile of marbles and a pile of beach balls have spherical shape and differing sizes; the porosities are identical due to the similar shaping.

Permeability – Measures the transmission property of the media and the interconnection of the pores. Related to hydraulic conductivity and transmissivity. (more later) Good aquifer – High porosity + High permeability •Sand and gravel, sandstone, limestone, fractured rock, basalt Aquiclude, Confining bed, Aquitard – "impermeable" unit forming a barrier to groundwater flow. •Granite, shale, clay

86 Classify Porosity according to the Origin?

Primary •A function of grain size distribution, also packing •Decreases with depth – compaction and pressure solution. Porosity increases as depth decreases. This is on account of the weight on top of the deeper materials. Porosity also tends to increase with grainsize.

Secondary •Dissolution •Fracture



87 **How many types of Porosity?**

•Intergranular. Between grains, mostly part of the effect of porosity, but also dead-end pores.
•Intragranular. Within grains. Usually not considered part of the effective porosity. Incredible wide range of widths and length scales •Simple dichotomous model - dual porosity.

88 **What is the distribution of the world's water?**

Salt water in oceans: 97.2% **Ice caps & glaciers**: 2.14% **Groundwater**: 0.61% **Soil moisture**: 0.005% **Atmosphere**: 0.001% **Fresh surface water**: 0.0009%

89 **What is the difference between the saturated and the unsaturated zones of ground water?**

the saturated zone has a higher porosity than the unsaturated zone
the saturated zone has a lower porosity than the unsaturated zone
the pore spaces in the saturated zone are completely full of water; the pore spaces in the unsaturated zone are not completely full of water.
the pore spaces in the saturated zone are not completely full of water; the pore spaces in the unsaturated zone are completely full of water

90 **What is A manometer?**

Manometer is a vertical tube in a pressurized water pipe used to measure pressure in the pipe.

91 What is A piezometer?

Piezometer is a vertical tube with an open or slotted interval (usually called the screened interval or just the screen) inserted into the ground and used to measure hydraulic head in an aquifer; it is basically a well constructed for the sole purpose of measuring groundwater levels.

92 What are Limits of Darcy's Law?

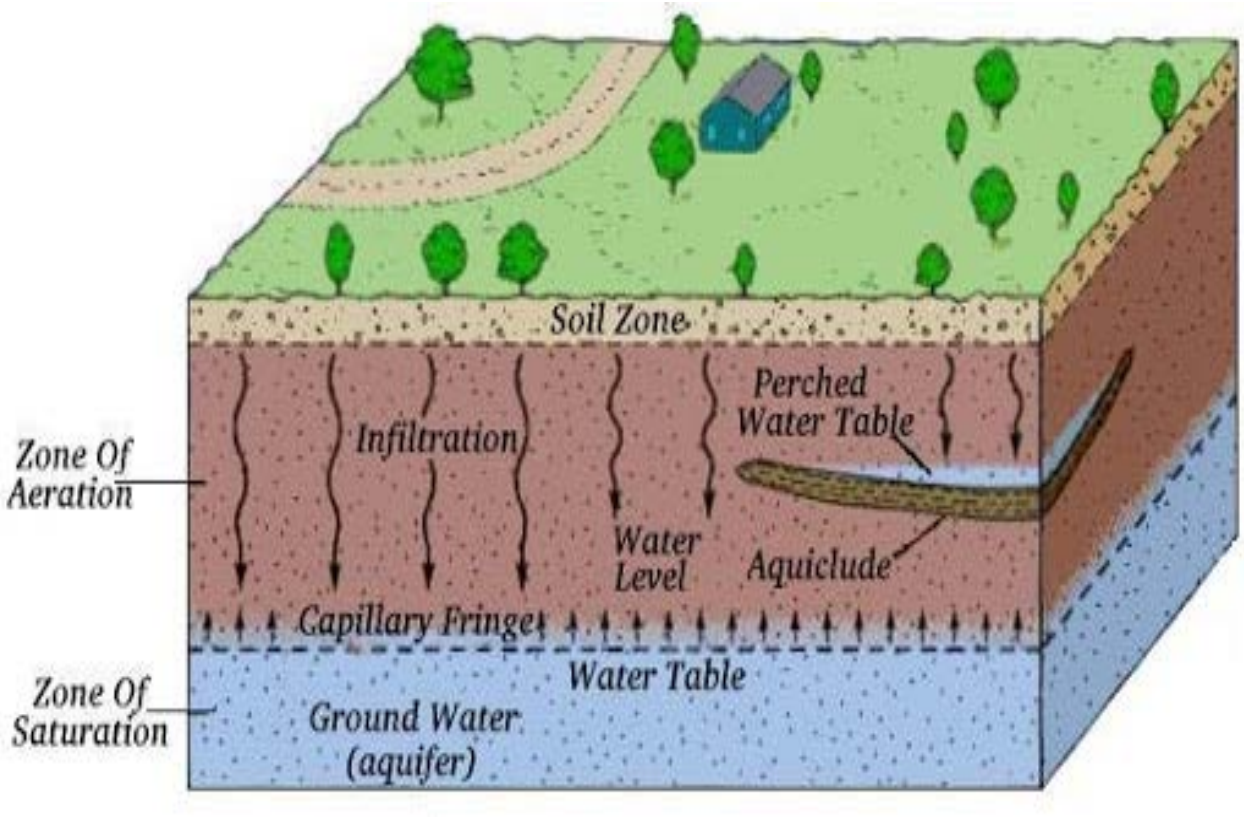
Although Darcy's law is regarded as a fundamental relationship in the Earth sciences, it does have limitations, and there is a range of conditions over which it is valid. **Upper Limit** One of the assumptions inherent in Darcy's law is the assumption of laminar flow. Darcy's law is not valid above the onset of turbulence in the system, because the discharge is no longer linearly proportional to the gradient. **Lower Limit** There is a lower limit, called the threshold gradient, where fluid viscosity is too strong for the gradient to overcome the resistance to flow.

93 Why Darcy's law is still widely used?

Because:
1) groundwater systems rarely become turbulent, and
2) at gradients near the threshold gradient, flow is generally so small we can ignore it.

94 What is meant by Well Efficiency?

Well **efficiency refers** to the difference between the expected performance of a well and the actual performance. What it basically means is that the water pumped into a well will lose some amount of energy from turbulence in the well screen or filter pack, and this loss of energy will result in lower heads in the well.



95 What is groundwater flow systems?

Is a three-dimensional entity that has the following components: **Boundary Conditions** – has some physical dimensions and some real boundaries. **Recharge** – some area where water is getting into the flow system. **Discharge** – some area where water is exiting the system

96 What is Heterogeneity?

Heterogeneity refers to variations with respect to location. A parameter like permeability will vary from place to place in a flow system, depending upon the rock types and variations in sediment characteristics (like grain size). A common example of heterogeneity in a flow system is interbedded sand and clay layers in a fluvial depositional system.

97 What is Anisotropy?

Anisotropy refers to variations with respect to direction. Layering is one form of anisotropy; in a layered system of interbedded sand and clay, the horizontal permeability will be much greater than the vertical permeability. **Anisotropy** can also result from sedimentary structures formed during deposition, both on a large scale (like channel sands interspersed with overbank deposits in a fluvial system) and on a smaller scale (cross-beds, graded bedding). More significantly, geologic structures like fractures are frequently responsible for anisotropic aquifers.

98 What is the difference between Advection and Dispersion?

Mass transport refers to the movement of particles in groundwater systems. There are two basic processes that move particles through groundwater systems. These are **advection** and **dispersion**.

Advection As groundwater flows through a porous media, it will carry particles along with it. This process is called advection.

Dispersion In real groundwater systems, advection is usually responsible for moving the largest quantity of mass. However, as the contaminant moves through the subsurface, several processes act on it and cause the contamination to spread out, resulting in variations in the concentration throughout the contaminated area. This spreading of particles in the subsurface is called dispersion, or sometimes hydrodynamic dispersion.

99 How many types of Dispersion?

Dispersion parallel to the flow vector is called longitudinal dispersion, while dispersion perpendicular to the flow vector is called transverse dispersion. Longitudinal dispersion spreads out the contaminant in the direction of flow, while transverse dispersion spreads it out laterally (to the side) as the contaminant moves with flow.

100 What are kinds of Humidity?

Humidity refers to the amount of moisture in the air; more specifically:
Absolute humidity – mass of water per unit volume of air (usually grams water per cubic meter of air)
- **Saturation humidity** – maximum amount of moisture the air can hold at a given temperature
- **Relative humidity** – the absolute humidity over the saturation humidity (i.e., the percent ratio of the amount of moisture in the air to the total amount it could possibly hold).

101 What is Potential Evapotranspiration?

is the water loss that would occur if there is an unlimited supply of water available for transpiration and evaporation In reality, the amount of water that transpires or evaporates is limited by the amount of water that is available. If the amount of water available is less than the potential, then the **actual evapotranspiration** will be lower than the potential.

102 What is Discharge?

Discharge is defined as the volume of water moving past a point on a stream in a given period of time. In the simplest terms, stream discharge (Q) is equal to the velocity of the water (v) times the cross sectional area of the stream (A), or Q = vA

103 What is Saturation?

At the surface of the Earth, the soil, sediment, or rock will have some porosity, and some fraction of that porosity will contain water. This fraction of porosity that contains water is called the degree of saturation(Sd), and is defined as:

Sd = Volume $_{water}$ / Volume $_{voids}$

The degree of saturation tends to increase with depth, and the point where the degree of saturation reaches 100% marks the boundary between the saturated zone below and the unsaturated zone above.

104 What is Water table?

Water table is defined as the point in an unconfined aquifer where the pore-water pressure and the atmospheric pressure are equal, and-the level to which water will rise in a well completed in an unconfined aquifer.

105 What is Tensiometer?

Tensiometer is used to measure matric head (also called soil suction). These can be installed at varying depths to infer moisture profiles. Usually these are installed between 15 cm and 1 meter below the surface.

106 What is Lysimeter?

Lysimeter like a tensiometer, but instead of measuring matric potential, it is used for sampling of the moisture in the pore spaces of the soil.

107 Define Storativity?

Groundwater storage of confined aquifer is related to the compression and expansion of pore spaces.
Storativity (S) is defined as: volume of water pumped per area (m3/m2= m) / amount of pressure head drop in the aquifer (m). S is proportional to the thickness (y, m) and compressibility (α, m^2N^{-1}) of the aquifer. $S = \rho g \alpha y$ $\rho = 1000$ kg m^{-3} $g = 9.8$ m s^{-2} .

108 What are Geologic relations of groundwater?

Valley alluvium ...good unconfined aquifer used as "filter" for pumping stream water
Fractured rock ...widely used, but occurrence is sporadic need to locate fractured zones. How?
Sand/gravel layers in sedimentary sequence ... most common aquifers

109 What is the ecological function of groundwater?

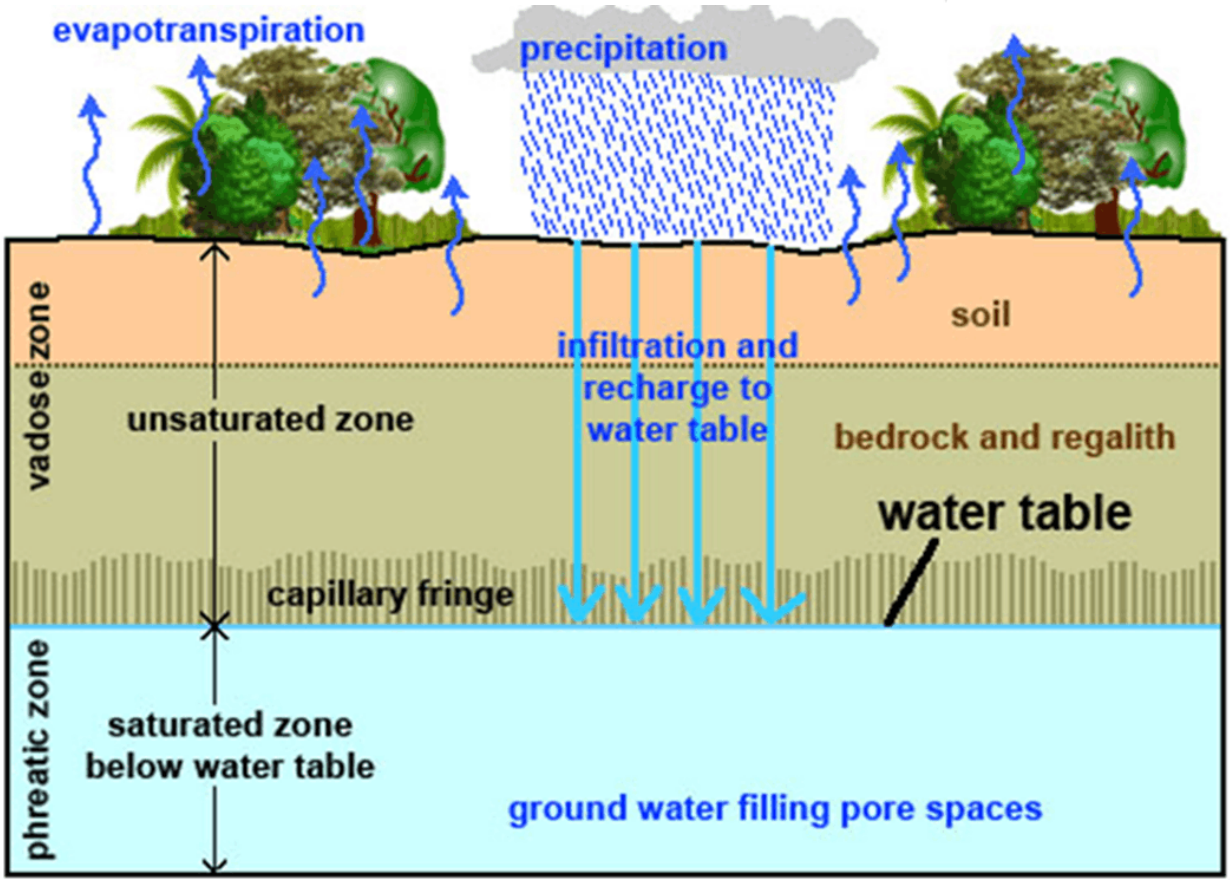
Groundwater has important ecological functions: (1) sustaining baseflow (2) stabilize temperature (3) supply nutrients (4) support stream-side (riparian) vegetation

110 What are the Effects of pumping?

Pumping induces "drawdown" of water table or hydraulic head. As a result a cone of depression forms around the pumping well. Higher pumping rates induce larger, deeper cones.

111 What is Vadose Zone?

The **vadose zone**, also termed the **unsaturated zone**, is the part of Earth between the land surface and the top of the phreatic zone, the position at which the groundwater (the water in the soil's pores) is at atmospheric pressure ("vadose" is from the Latin word for "shallow"). Hence, the vadose zone extends from the top of the ground surface to the water table.



112	An aquifer can hold water _____ and the state of water is _____		
A.	Permanently – State of flow	C.	Permanent – State of stagnancy
B.	Temporarily – State of flow	D.	Temporary – State of stagnancy

113 **The quantity of water that can be withdrawn annually and also the rate at which this withdrawal could be made without adversely affecting the inventory of the aquifer is called**

A.	Annual yield	**C.**	Operational yield
B.	Percent yield	**D.**	Monthly yield

114 **When an aquifer is used to artificially recharge by making it pass through an intervening layer, the aquifer acts as _____**

A.	A cooling agent	**C.**	An odors agent
B.	An aerating agent	**D.**	A filter plant

115 **When would the dam become irrelevant?**

A.	When the rocks are strong	**C.**	When the rocks are porous
B.	When the rocks are impermeable	**D.**	When the rocks are weathered to a certain extent

116 **Which quality of rock should be known properly for the foundations of dams, reservoirs, etc.?**

A.	Color knowledge	**C.**	Hydrogeological
B.	Geological	**D.**	History of the formation of rocks

117 **Groundwater is a source of trouble at which place?**

A.	Plains	**C.**	Rivers
B.	Slopes	**D.**	Lakes

118 **An associated protection of rising water-table is the development of _____**

A.	Loss of nutrients	**C.**	Salinity of water
B.	Loss of good quality of water	**D.**	Increase in turbidity

119 **The root system of crops in water-logged areas get _____**

A.	Decomposed	**C.**	Photosynthesised
B.	Enriched with nutrients	**D.**	Growth inhibited

120 **Which is formed when a section of impermeable rock forces ground-water to move laterally and emerge onto the surface of Earth?**

A.	an aquifer	**C.**	a well
B.	a geyser	**D.**	a spring

121 **The drilling for freshwater increases along a coastal area. What is a likely consequence of this action?**

A.	the loss of water resources in estuaries	**C.**	the destruction of estuaries
B.	decrease in salt concentration in inlet waterways	**D.**	an intrusion of salt water into aquifers

122 **What type of water is contained in the water table and in aquifers?**

A.	surface water	**C.**	ground water
B.	Loss of good quality of water	**D.**	underground stream

123 **What process occurs when rain water infiltrates into aquifers?**

A.	discharge	**C.**	recharge
B.	porosity	**D.**	permeability

124 **Non-point source pollution is mainly transported to bodies of water through _____**

A.	precipitation	**C.**	runoff
B.	karst topography	**D.**	sinkhole

125 **How could a long-term decrease in precipitation impact an area?**

A. It could increase the average water level of lakes in the area.
B. It could decrease the amount of possible infiltration in the area.
C. It could increase the amount of flooding in the area.
D. It could decrease the possible amount of damage to crops in the area.

126 **Which problem would occur if the groundwater is drawn too much near the seawater shoreline?**

A.	Drawdown will cause the well to go dry.	**C.**	The well will not be deep enough to get water.
B.	Drawdown will cause salt water intrusion	**D.**	A cone of depression will form around the well.

127 **What problem/s would occur if the groundwater is drawn too much?**

A.	Formation of Karst topography.	**C.**	Formation of caves and sinkholes.
B.	Drawdown will cause salt water intrusion.	**D.**	All of the above.

128 **Which type of soil has the highest infiltration or percolation rate?**

A.	clay	**C.**	sand
B.	silt	**D.**	loam

129 **Which type of soil has the highest probability of causing a flashfloods?**

A.	<u>clay</u>	**C.**	sand
B.	silt	**D.**	gravel

130 **Which land has a higher infiltration or percolation rate?**

<u>A. land covered with vegetation</u>

B. land covered with asphalt and concrete

131 **Which slope has a higher infiltration rate?**

A. high slope <u>B. low slope</u>

132 **Which slope has faster runoff and higher probability of erosion ?**

<u>A. high slope</u> B. low slope

133 **An aquifer provides water for a _____.**

A. pumping well B. artesian well

134 **Artificial recharge is done to prevent the occurrence of _____**

A.	sinkhole	C.	faulting
B.	subsidence	D.	All of the above

135 **Which of the following pollutants is mainly from agricultural source?**

A.	chloride	C.	greenhouse gas
B.	nitrate	D.	ozone

136 **Rock or a sediment that contains groundwater is called an…?**

A.	Aquifuge	C.	Aquifer
B.	aqueduct	D.	Aqualith

137 **What describes the infiltration of water from the surface to the water table?**

A.	Through-flow	**C.**	Base-flow
B.	Permeation	**D.**	Recharge

138 **What is the name for the lowering of the water table by pumping, to allow excavation of a mine ?**

A.	Depressurizing	**C.**	Desaturating
B.	Dehydrating	**D.**	Dewatering

139 **The percentage of water that can be stored in a rock, compared to the aggregate volume of the whole rock, is called ?**

A.	Storativity	**C.**	Porosity
B.	Permeability	**D.**	Transmissivity

140 **What is another word for the unsaturated zone above the water table?**

A.	Vadose zone	**C.**	Phreatic zone
B.	Conductive zone	**D.**	Darcian zone

141 **The thickness of an aquifer may be represented on what kind of a map?**

A.	Isobar	**C.**	Isohyet
B.	Isopach	**D.**	Isobath

142 **What is another term for ' Water table ' ?**

A.	Transition zone	**C.**	Piezometric surface
B.	Confining surface	**D.**	Saturation point

143 **Which of the following reservoirs contains the most water?**

A.	Atmosphere	**C.**	groundwater
B.	biosphere	**D.**	lakes and rivers

144 **How much of the Earth's water is stored in underground aquifers?**

A.	less than 1%	**C.**	about 10%
B.	about 5%	**D.**	about 20%

145 **What is the process by which water enters the small pore spaces between particles in soil or rocks**

A.	Transpiration	**C.**	precipitation
B.	infiltration	**D.**	sublimation

146 **Which of the following terms is a measure of the amount of water vapor in the air as a proportion of the maximum amount the air could hold at the same temperature?**

A.	dew point	**C.**	evaporation rate
B.	sublimation point	**D.**	relative humidity

147 **The percentage of a rock's total volume that is taken up by pore space is called the _____ .**

A.	Permeability	**C.**	aquifer
B.	recharge	**D.**	porosity

148 **Permeability is _____ .**

a. the ability of a solid to allow fluids to pass through
b. the process by which plants release water vapor to the atmosphere
c. the amount of water vapor in the air relative to the maximum amount of water vapor the air can hold.
d. the percentage of pore space in the rock

149 **The best groundwater reservoirs have _____?**

A.	low permeability and low porosity	**C.**	high permeability and low porosity
B.	low permeability and high porosity	**D.**	high permeability and high porosity

150 **The ability of an Earth material to transmit water is a measure of its:**

A.	Porosity	**C.**	chemical cement
B.	aquifer characteristics	**D.**	permeability

151 **The lowering effect on the water table about the base of the well stem is called a(n):**

A.	Aquiclude	**C.**	cone of depression
B.	artesian surface	**D.**	speleothem

152 **A local water table positioned above the regional water table is said to be:**

A.	Stranded	**C.**	displaced
B.	perched	**D.**	depressed

153 **Which of the following statements about the water table is false:**

a. the water table changes when discharge is not balanced by recharge
b. the water table is generally flat
c. the water table is above the land surface in lakes
d. the water table is depressed near high volume pumping wells

154 **The boundary between the saturated zone and the unsaturated zone is called the_____ .**

A.	water table	**C.**	aquiclude
B.	aquifer	**D.**	porosity

155 **The infiltration of water into the subsurface is the _____ .**

A.	Influent	**C.**	discharge
B.	effluent	**D.**	recharge

156 **What is the term for a relatively impermeable geologic unit?**

A.	an artesian	**C.**	an aquifer
B.	an aquiclude	**D.**	none of these

157 **Excessive pumping in relation to recharge can cause _____ .**

A.	the water table to decline	**C.**	the well to go dry
B.	a cone of depression to form	**D.**	all of these

158 **The most abundant, natural acid is:**

A.	Nitric	**C.**	carbonic
B.	hydrochloric	**D.**	citric

159 **Most groundwater withdrawn in the United States is used for _____ .**

A.	Industry	C.	drinking water
B.	irrigation	D.	swimming pools

160 **In what types of rock do most caves form?**

A.	Granite	C.	limestone
B.	shale	D.	sandstone

161 **Stalactites and stalagmites in caves are composed of _____ .**

A.	Quartz	C.	halite
B.	alkali feldspar	D.	calcite

162 **Hard water contains large amounts of _____ .**

A.	Lead	C.	calcium
B.	sodium	D.	silicon

163 **Most of the water coming out of continental hot springs is _____ .**

A.	meteoric water	**C.**	seawater
B.	magmatic water	**D.**	metamorphic water

164 **Which slope has a lower infiltration rate?**

A.	high slope	**C.**	Steep slope
B.	low slope	**D.**	Intermediate slope

165 **With respect to the Earth's land surface, which of the following expressions is correct?**

A.	precipitation = evaporation- runoff	**C.**	precipitation = evaporation + runoff
B.	precipitation = runoff - evaporation	**D.**	precipitation = evaporation * runoff

166 **Which one of the following features is a sure sign of karst?**

A.	Sinkholes	**C.**	cones of depression
B.	artesian wells	**D.**	speleothems

167 **Which of the following statements is true?**

A.	cool air can hold more water vapor than warm air	**C.**	cool air and warm air always hold the same amount of water vapor
B.	warm air can hold more water than cool air	**D.**	air cannot contain water vapor

168 **Which of the following rocks has the highest permeability?**

A.	an unfractured shale	**C.**	an uncemented sandstone
B.	a cemented sandstones	**D.**	all of these rocks have approximately the same permeability

169 **Which of the following materials has the lowest porosity?**

A.	Shale	**C.**	granite
B.	gravel	**D.**	sandstone

170 **As groundwater flows through a porous media, it will carry particles along with it. This process is called .....**

A.	advection	**C.**	aquiclude
B.	aquifer	**D.**	porosity

171 **Influent streams are _____**

A.	more common in arid regions	**C.**	only found in areas of permafrost
B.	more common in humid regions	**D.**	sinkhole

172 **Excessive pumping in relation to recharge can cause_____**

A.	the water table to decline	**C.**	the well to go dry
B.	a cone of depression	**D.**	all of these

173 **Sinkholes are a possible danger in regions underlain by what type of bedrock?**

A.	Granite	**C.**	shale
B.	sandstone	**D.**	limestone

174 **Water that is good enough to drink is called _____.**

A.	potable water	**C.**	surface water
B.	groundwater	**D.**	artesian water

175 **Which of the following can contaminate an aquifer?**

A.	Landfills	**C.**	gas stations
B.	agricultural regions	**D.**	all of these

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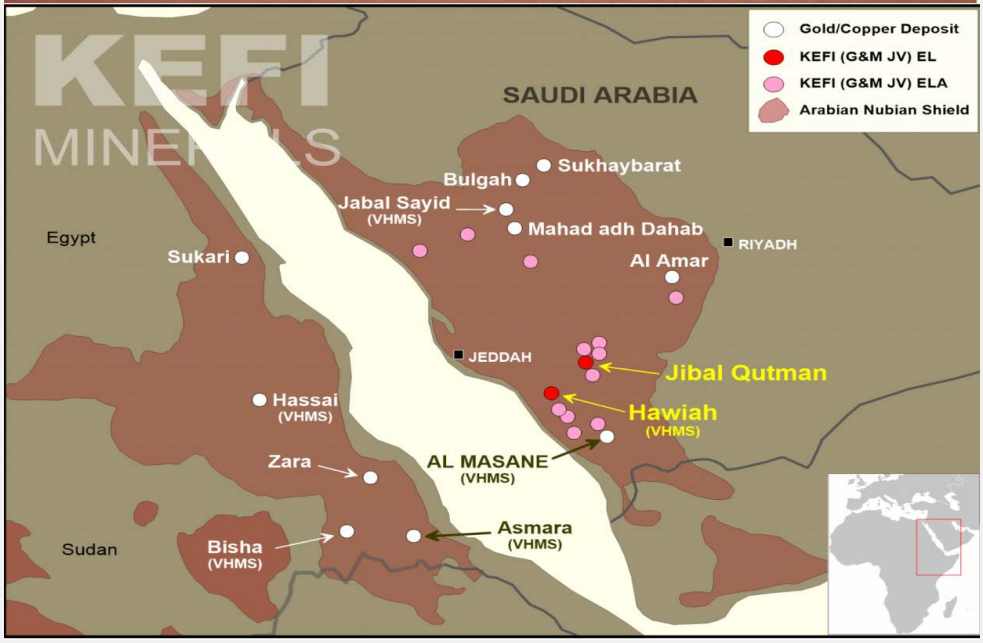
Questions & Answers in Economic Ores



Economic Ores

Introduction

Mineral resources are the key material basis for socio-economic development. Statistical results show that more than 95% of energy used by mankind, 80% industrial raw materials and 70% raw materials for agricultural production are from mineral resources. Mineral resource is the mineral deposit consisting of useful concentration that may or may not exceed economic cost for obtaining the valuable minerals. The technological process, the needs of the economy and prices in the market, depends on whether and when the rock/mineral becomes raw material. Industrial minerals (the 'nonmetallics') have chemical and/or physical properties that are of importance, especially in various industrial processes and for the manufacture of chemicals and fertilizers.

Economic Ores

1 What is Economic geology?

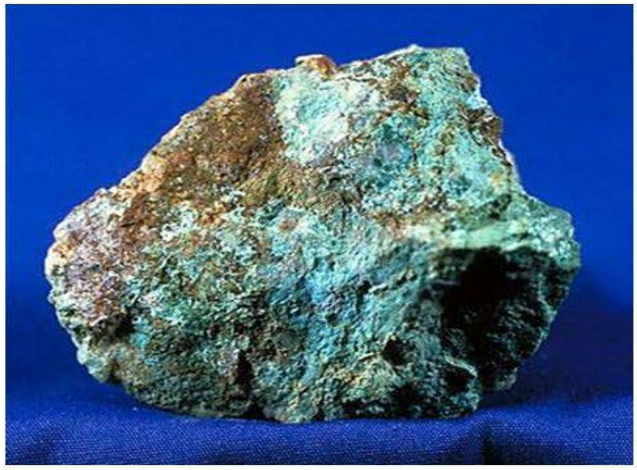
Economic geology is a scientific discipline concerned with the distribution of mineral deposits, the economic considerations involved in their recovery, and an assessment of the reserves available. Economic geology deals with metal ores, fossil fuels (e.g., petroleum, natural gas, and coal), and other materials of commercial value, such as salt, gypsum, and building stone. It applies the principles and methods of various other fields of the geologic sciences, most notably geophysics, structural geology, and stratigraphy (qq.v.). Its chief objective is to guide the exploration for mineral resources and help determine which deposits are economically worthwhile to mine. Specialists in economic geology often assist in the extraction of the mineral commodities as well.

2	What is an Ore?

A type of rock that contains minerals with important elements including metals in a quantity that can be exploited extracted from the rock at a profit and economic cost.

What is an Ore?

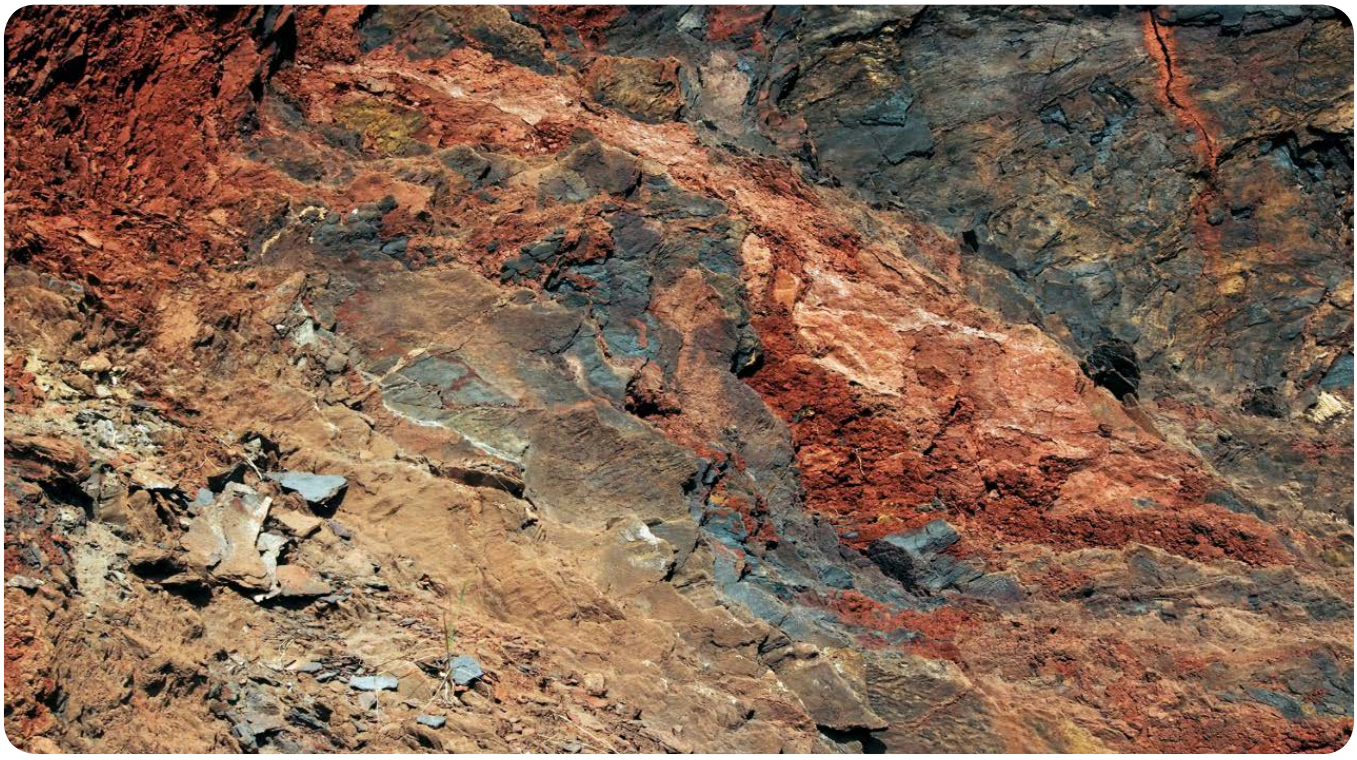
- A naturally occurring solid material, which contains a mineral or metal.
- The ores are extracted through mining at low costs and then refined to extract the valuable element.



Economic Ores

3 What is Ore deposit ?

Ore accumulation. Parts of the crust, where ores are concentrated. Natural concentration of an ore mineral in a massive rock body is defined as an ore deposit. Hence the definition of an ore deposit is also size dependent. Most ore deposits are named according to their location. Ore grade is the concentration of economic mineral or metal in an ore deposit. Gangue is commercially worthless material that surrounds, or is closely mixed with, a wanted mineral in an ore deposit.



4 What are gangue minerals?

A few non-metallic minerals are often found associated with an ore-mineral. These have be separated from the ore before the same is processed for extraction of the metal. These associated minerals are called gangue minerals.

5 Classify ore deposits according to their the Relation with host-rock?

1. Syngenetic Ore Deposits 2. Epigenetic Ore Deposits.

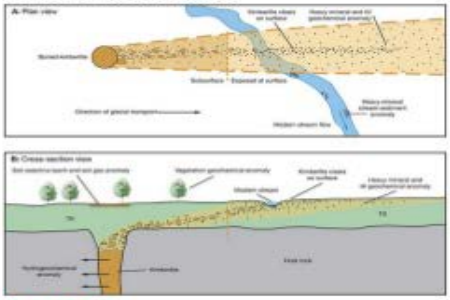
Syngenetic Ore Deposits : Ore deposits which are formed as the same time as the enclosing rock. Sedimentary Ore Deposits are the example of syngenetic Ore Deposits.

Epigenetic Ore Deposits : Ore deposits that are formed later than the enclosing rock.. Hydrothermal ore deposits are the example of epigenetic ore deposits.

Endogenic Ore Deposits Which formed in the Sub-surface, such as: Chromite Deposits . Magnetite Deposits . Diamond Deposits . Sulfide Deposits

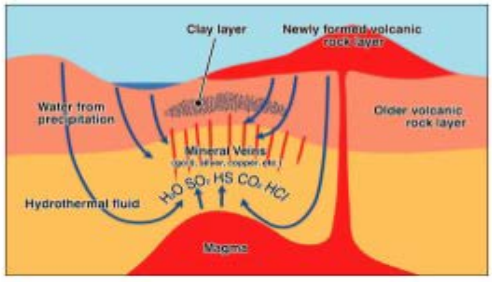
Exogenic Ore Deposits Which are formed on the Surface, such as: Residual Weathering : Bauxite Deposits. Mechanical Weathering : Placer Deposits.

Syngenetic: refers to ore deposits that form at the same time as their host rocks.

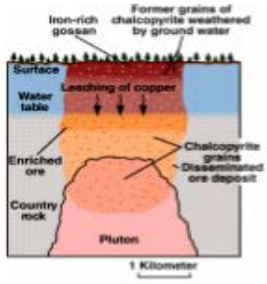


Hypogene: refers to mineralization caused by ascending hydrothermal solutions.

Epigenetic: refers to ore deposits that form after their host rocks.



Supergene: refers to mineralization caused by descending solutions.



6 What are Hypogene and Supergene?

Hypogene: refers to mineralization caused by ascending hydrothermal solutions.

Supergene : refers to mineralization caused by descending solutions

7 Classify ore deposits according to their Genesis?

1.Magmatic Ore Deposits
2. Metamorphic Ore Deposits
3. Sedimentary Ore Deposits

8 Classify ore deposits according to their geologic age?

1. **Archean** : Metallic Mineral Deposits like Fe, Mn, Ni, Chromite etc.
2. **Proterozoic** : Non-Metallic Ore Deposits like building stones Barytes, asbestos, diamond etc.
3. **Paleozoic** : Coal, Gypsum etc.
4. **Mesozoic** : Coal/Lignite
5. **Tertiary:** Petroleum, Kaolin, Bauxite etc.
6. **Quaternary**: Placers Gold, Tin, Ilmenite etc.

9 Classify ore deposits according to the composition of the ore mineral?

1. Metallic ore minerals
2. Non- Metallic ore minerals
3. Radio-active ore minerals
4. Petroleum .

10 **Define Epithermal, Mesothermal and Hypothermal?**

Hydrothermal ore deposits formed at shallow depths(less than 1500 meters) and fairly low temperatures (50–200 °C).

Mesothermal: hydrothermal ore deposits formed at intermediate depths (1500–4500 meters) and temperatures (200–400 °C).
Hypothermal: hydrothermal ore deposits formed at substantial depths (greater than 4500 meters) and elevated temperatures (400–600 °C

11	What are types of Types of Ore Deposits?

There are several types of ore deposits: **Magmatic**: crystallization of minerals within a body of magma. **Hydrothermal**: hot fluids released as magma cools, minerals precipitate from fluids. **Sedimentary:** precipitation of minerals from a lake or ocean water . **Placer deposits:** deposition of metals in a river or stream. **Residual:** concentrations of minerals produced by weathering and chemical reactions with oxygen and water. This is a very broad classification. There are many sub-types and even more types.

12 What are the geologic conditions and characteristic of ore deposits?

1) Shape of ore deposits 2) Dip ore deposits 3) Thickness ore deposits 4) Depth of ore deposits 5) Structure of ore deposits 6) Ore value and profitability of mining 7) Stability of ore rocks 8) Chemical and mineral characteristics of ores 9) Lessening of ore deposit 10) Degree of breakability.

13 What is the Structure of ore deposits according to structure of ore body?

The deposits can be classified into:
I. Massive ore.
II. Laminated ore.
III. Jointed ore.
IV. Loose ore.

14 What is the Stability of ore rocks?

Stability is ability of massif to resist caving for a certain period of time. The stability of ore rocks is usually depending on amounts of joints and laminations in the ore rocks as well as hardness of the ore rocks. Therefore, the ore rocks may be divided into:1. Very unstable ore rock (like friable sandstones) 2. Unstable ore rock.3.Medium ore rock. 4. Stable ore rock. 5. Very stable ore rock.

15 What are Chemical and mineral characteristics of ores?

1. Native ores 2. Noble metals 3. Sulphide ores: chalcopyrite (**$CuFeS_2$**), Galena (**PbS**), pyrite (**FeS**), sphalerite (**ZnS**), stibnite (**Sb_2S_3**), and molybdnite (**MoS_2**). 4. Oxidized ores: Hematite (**Fe_2O_3**), Magnetite (**Fe_3O_4**), Goethite (**$Fe_2O_3.nH_2O$**), (**MnO_2**), Cuprite (**CuO_2**), Cassiterite (**SnO_2**), and Chromite (**$FeCrO_3$**). 5. Silicate ores: Zircon (**$ZrSiO_4$**) and Beryl (**$Al_2Be_3Si_6O_8$**).

16 What is the Lessening of ore deposit?

I. Oxidation (iron deposit, sulphide deposits)

II. Caking (Mn deposits)

III. Self ignition (Sulphur, coal)

17 Define Degree of breakability?

Breakability is the resistance of a rock parts to separation from the mass. According to its breakability, every rock falls into one of the following five groups: **Friable and flowing** (ex. sand, peat, topsoil); **Soft** (like. Clay**); Brittle** (ex. Sandstone, limestone, shale, coal**); Strong** (ex. granite, magnetite**); Very strong** (ex. quartzite, diabase, porphyry).

18 What is the Economic Impact on Mineral Supplies?

A) Mineral prices are low because of subsidies: depletion allowances and deduct cost of finding more.
B) Mineral scarcity does not raise the market prices.
C) Mining Low Grade Ore: Some analysts say all we need to do is mine more low grade ores to meet our need: 1) We are able to mine low grade ore due to improved technology. 2) The problem is cost of mining and processing, availability of fresh water, environmental impact

19 What are Stock works used for ?

The term, stock works, is used for hydrothermal deposits that occur in veins or fissures of exceptionally small size, but in good number, within a limited space, traversing the body of rock profusely.

20 In which forms do magmatic ore deposits occur ?

Magmatic ore deposits commonly occur in three forms: segregations, disseminations and injections.

21 List the conditions of hydrothermal formation?

The three essential conditions for the formation of hydrothermal deposits are: highly active and enriched fluids, suitable pathways for their migration through the rocks, and suitable physic-chemical environment for their deposition to take place**.**

22 What is “dispersion halo” of a mineral deposit ?

Dispersion halo is a zone of “eluvium-deluvium” which has been enriched by a characteristic element derived from a primary deposit without regard for the state of aggregation of the element. The term embraces the areal aspects of the pattern, and the processes by which the mineral deposit passes from a state of concentration to a state of secondary dispersion.

23 What are Meteorites?

Meteorites are rock fragments dislodged from a celestial body, launched into interplanetary space, which pass through the Earth's atmosphere and land on the surface. However, rocks that similarly fell to the surface of the Moon and Mars (or any other planetary body) are also meteorites. Additionally, a rock launched from a planetary body and falls back to that same body is also considered a meteorite. A comprehensive definition (from Rubin and Grossman 2014) is a meteorite is a natural, solid object larger than 10 µm in size, derived from a celestial body, that was transported by natural means from the body on which it formed to a region outside the dominant gravitational influence of that body and that later collided with a natural or artificial body larger than itself (even if it is the same body from which it was launched).

Economic Ores

24 What geologic processes cause gold ore to form?

Gold ore is not pure metal itself but rather a formation of rock that includes a high quantity of this valuable gold. Gold itself is not produced by geologic processes, instead being formed in the heart of a dying star as elements fuse together. The primary geologic processes that cause gold ore to form are mountain uplifts, the result of continental plates colliding and forcing mountains upwards and upwards. Most of the world's productive gold mines are found in mountains, such as the Phoenix gold mine in Colorado, because the upthrust brings gold in the Earth's crust towards the surface. As this gold is exposed to weathering, it erodes away from the rock ore to become nuggets or dust, which are most easily found in mountain streams. Most gold rushes in history took place in or around major mountain formations.

25 Gold is found in native form and can therefore be considered as a mineral, but sodium is invariably found combined with other elements. What is the reason for this difference?

Gold is an inactive element, which means that it has little tendency to react chemically with other elements to form compounds. Sodium, on the other hand, is an extremely active element and combines readily with other elements, hence it is never found in the native state.

26 What are Deluvial placers?

Deluvial placers is the term used when gravity is the agency involved; such placers would be found along the foot hills and talus slopes.

27 What are Gash-veins ?

Gash-veins are narrow, sloping and thick-bodies deposits of minerals deposited in solution-fissures or cracks of the host rock which is generally a carbonate rock like limestone.

28 Define Ladder-veins ?

Ladder-veins are commonly found in igneous rocks such as dykes and similar bodies and consist of transverse, roughly regularly spaced fractures that are filled with deposits of economic minerals.

29 Define Fissure-veins?

Fissure-veins may be defined as mineral bodies of elongated or tabular shape deposited in pre-existing fissures. The original fissures may be parallel or intersecting, radial or fan-shaped in pattern and that is also the shape of the resulting ore bodies.

30 What is the fluorescent response of characteristic minerals?

Scheelite, the carbonates, and fluorite give the most intense fluorescence:
Scheelite (CaWO4). Scheelite fluoresces very well, always under the rays of the mercury-quartz lamp. It fluoresces an intense blue (some-times green), making it easy to distinguish from the other minerals.
Carbonates. Among the stable minerals, calcite and aragonite are especially characteristic because of their sensitivity and variety of colors. With respect to ultraviolet and cathode rays there are two types of calcite. One does not fluoresce when irradiated; the other does. Under ultraviolet rays calcite fluoresces waxy-yellow, pink, or dark red. Under cathode rays the fluorescence is less varied, being yellow and fiery-yellow.
Fluorite. Fluoresces intense blue or bluish colors.
Cryolite. Does not fluoresce under the ultraviolet ray the mercury lamp, but under the rays of the spark discharger it gives a weak fluorescence and possesses a clear white phosphorescence. **Corundum**. Different types of corundum fluoresce differently.
Diamond.--Fluoresces with a light blue or yellow green color.
Apatite. Specimens from different deposits fluoresce different colors, such as pink, violet, green, or yellow.
Zircon. Fluoresces an intense orange which is easily distinguished from the fluorescence of other minerals.

31 What is Metallogeny?

Metallogeny is the study of the genesis of mineral deposits, with emphasis on their relationships in space and time to geological features of the Earth's crust. **Metallotect:** any geological, tectonic, lithological or geochemical feature that has played a role in the concentration of one or more elements in the Earth's crust. **Metallogenic Epoch:** a unit of geologic time favorable for the deposition of ores or characterized by a particular assemblage of deposit types. **Metallogenic Province**: a region characterized by a particular assemblage of mineral deposit types.

32 What is Europium?

Europium is a silvery-white rare-earth element with a pale yellow. It is a ductile metal and has the second lowest melting point and the lowest density of all rare-earth elements. Europium metal is commercially produced by isolation from rare-earth element-bearing minerals such as bastnäsite and more rarely monazite.

33 What are Types of ores mined from Earth?

Metallic : Copper, Gold, Silver, Graphite

Non-metallic : Diamonds/ gemstones, Salt, Gypsum

Fuel Oil : Natural gas, Coal, Uranium

Economic Ores

34 What is meant by Metal and Non-metal?

A metal is a solid material (an element, compound, or alloy) that is typically hard, opaque ,shiny, and features good electrical and thermal conductivity. Metals are generally malleable, fusible and ductile.• Currently, 91 out of the 118 total elements on the periodic table are classified as metals.

Non-metals are solids and gases and are not good conductors of heat and electricity. Non metals are chemical elements that form negative ions, have acidic oxides, and are generally poor conductors of heat and electricity.

35 What is Mineral system?

Mineral system can be defined as:“ all geological factors that control the generation and preservation of mineral deposits”. There are nine broad mineral systems: porphyry-epithermal, granite-related, iron oxide - copper- gold, subaqueous volcanic - related, mafic-ultramafic orthomagmatic, orogenic, basin-related, alkaline, and surficial

36 What is the definition of mine and mining?

Mine is any opening or excavation in the ground for extracting minerals, even if no actual production occurred, mine feature. **Mining**, process of extracting useful minerals from the surface of the Earth, including the seas.

37 **37. What are industrial minerals?**

Any rock, mineral, or other naturally occurring material of economic value, excluding metals, energy minerals, and gemstones• One of the non metallics • Includes aggregates

38 What are differences between critical and strategic minerals?

Minerals for military uses are strategic• Minerals for which a threat to supply could involve harm to the economy are critical• A critical mineral may or may not be strategic, while a strategic mineral will always be critical

39 Are all ores native (uncombined) elements such as Au, Ag, or Cu?

NO. Most are combined and have to be removed chemically. Ex. Iron from hematite

40 What is meant by Epigenesis?

Epigenesis is a term derived from the Greek (epi+genesis = after formation) that is primarily used to describe a geological process involving the addition, modification, and/or removal of minerals from a rock subsequent to its formation. It typically refers to a metasomatic process that has, as well as transforming the mineral assemblage, modified the chemical composition and even textural properties of the bulk rock via the addition or removal of elements.

41 Define Ferromanganese?

Ferromanganese (Fe-Mn) crusts and nodules are marine sedimentary mineral deposits, composed mostly of iron and manganese oxides. They precipitate very slowly from seawater, or for nodules also from deep-sea sediment pore waters, recording the chemical signature of these source waters as they grow. Additional elements incorporate via sorption processes onto the Fe-Mn oxides, including rare and valuable metals that can reach concentrations that are economically valuable.

42 Why aren't all feldspars zoned?

Kinetics, segregation. IF there is sufficient time, the crystals will re-equilibrate with the magma they are in – and reflect the total Na-Ca content of the magma. IF not, then different minerals of different composition will be present in zoned plagioclase or segregated from each other physically.

43 What are Metallogeny and Metallotect?

Metallogency is the study of the genesis of mineral deposits, with emphasis on their relationships in space and time to geological features of the Earth's crust. **Metallotect**: any geological, tectonic, lithological or geochemical feature that has played a role in the concentration of one or more elements in the Earth's crust.

44 What is Pegmatites?

Pegmatites are extreme **igneous rocks** that form during the final stage of a magma's crystallization. They are extreme because they contain exceptionally large crystals and they sometimes contain **minerals** that are rarely found in other types of **rocks**.

To be called a "pegmatite," a rock should be composed almost entirely of crystals that are at least one centimeter in diameter. The name "pegmatite" has nothing to do with the mineral composition of the rock. Most pegmatites have a composition that is similar to **granite** with abundant **quartz**, **feldspar**, and mica.

45	**What is the source of the gases detected over ore deposits?**

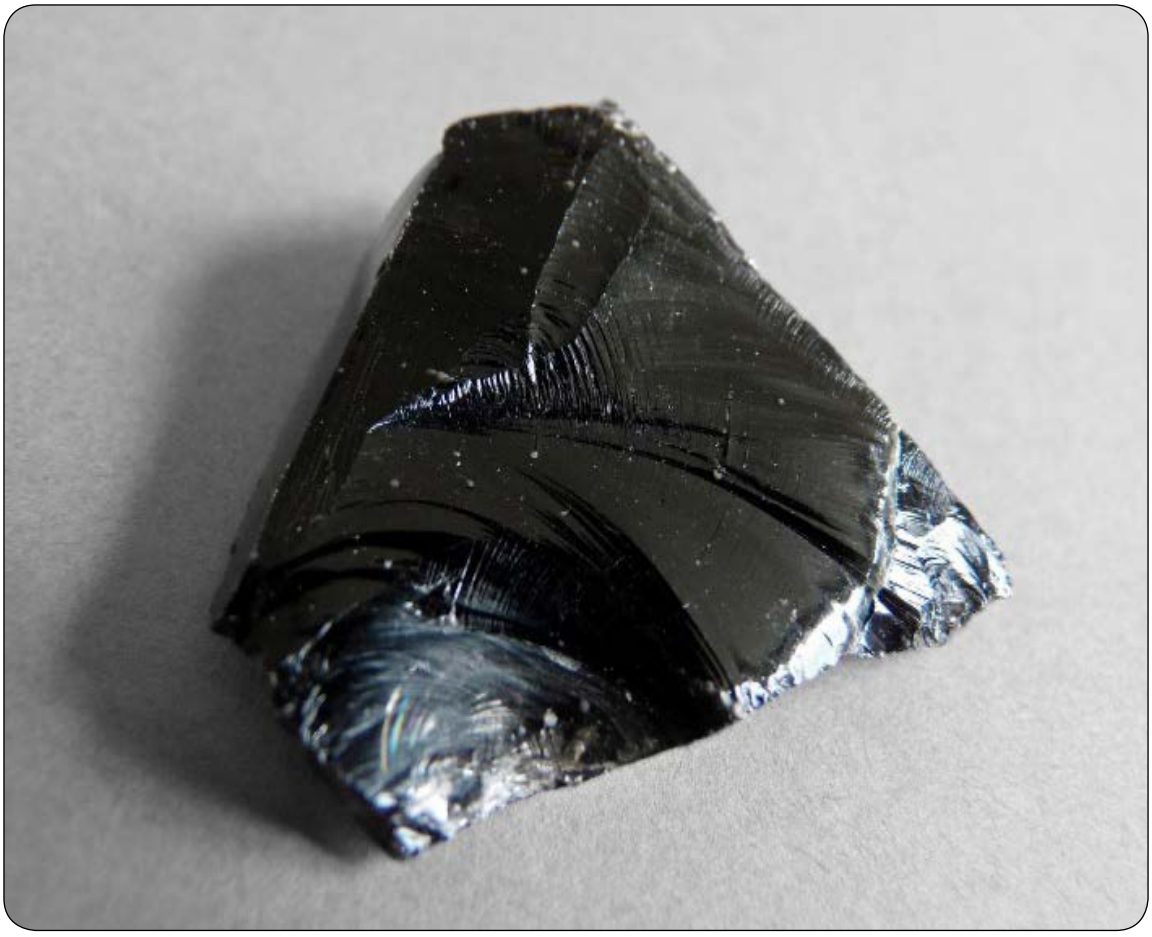
Possible sources of organic gases include methylated compounds from bio-oxidation, organic compounds incorporated in the hydrothermal fluids from sedimentary rocks, and oxidation reaction products, especially sulfur compounds.

46	**What is the cause of the holes found in many volcanic rocks such as pumice?**

Such holes were produced by bubbles of gas trapped in lava as it solidified.

47	What is the origin of the glasslike rock Obsidian ?

Obsidian forms from a rhyolite lava, which is rich in silica, that cools so rapidly that crystals do not have time to grow. The resulting rock, like glass, has a structure that is essentially that of a liquid.



48	**Distinguish between a dike and a vein.**

A dike consists of molten rock that has intruded into a fissure and hardened there; a vein consists of material that has precipitated in a fissure from solution in ground water.

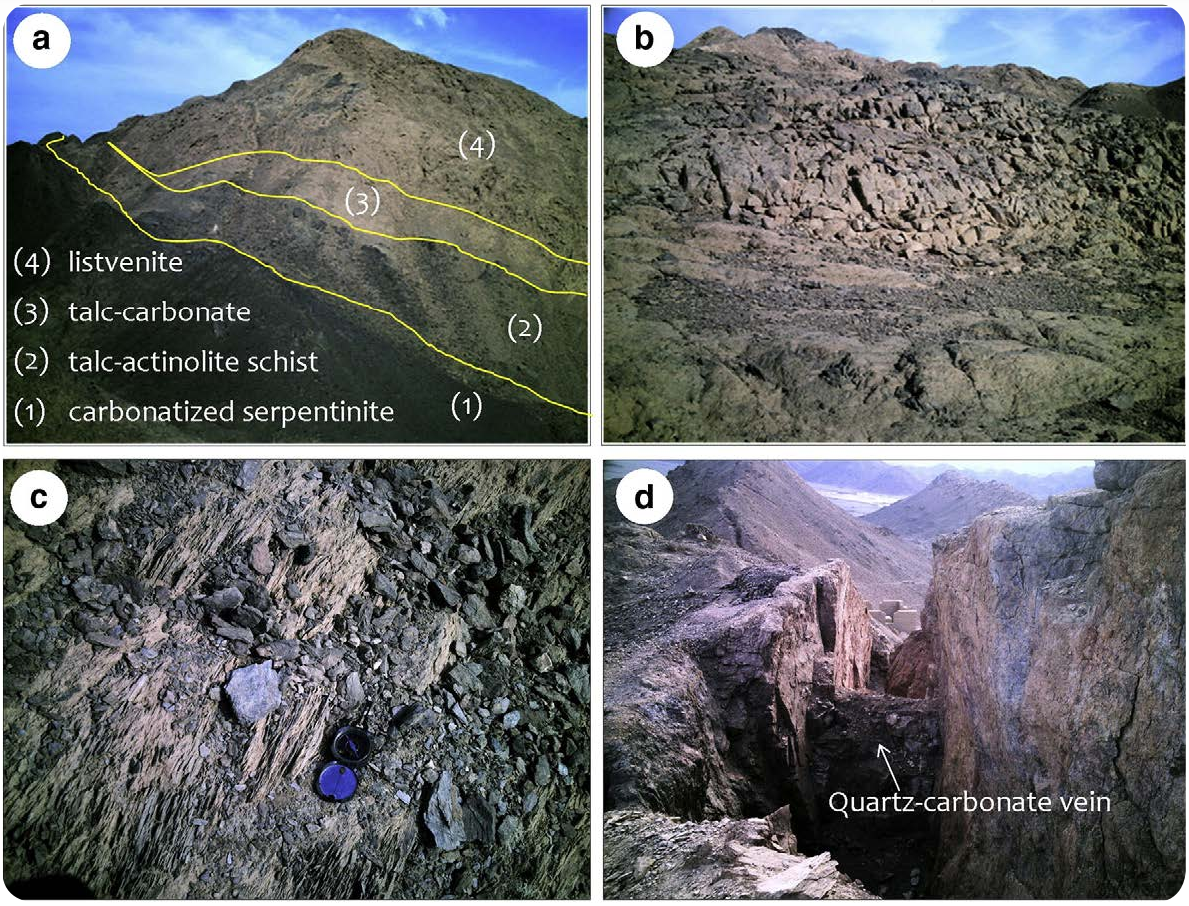
49	**What kinds of rocks are likely to be fund in (a) a batholith and (b) a dike ?**

(a) Because magma cools slowly in a batholith, coarse-grained igneous rocks such as granite, diorite, and gabbro are likely to be found .

(b) Magma may cool slowly or rapidly in a dike, depending on the circumstances. Hence both coarse-and fine-grained igneous rocks may be found; granite, diorite, gabbro, rhyolite, andesite, and basalt, for instance.

50	**50. Does any rock besides kimberlite decay into blue clay and then into yellow dirt/clay?**

Many minerals can decay into «blue» and/or «yellow» clay. Clay is just the state of minerals when they have been sufficiently decayed into small enough



51 What is Listvenite and how its formed?

Listvenite is a metasomatic rock composed of variable amounts of quartz, magnesite, ankerite, dolomite, sericite, calcite, talc and sulfide minerals. It is formed by interaction of mafic and ultramafic rocks with low to intermediate temperature CO2- and S-rich fluids, and is commonly found along the major fault and shear zones at terrane boundaries or major tectonic units in orogenic systems. As such, listvenite is spatially associated with ophiolites, greenstone belts and suture zones in orogenic belts. Listvenite occurrences are considered to represent key indicators for certain mineral associations connected with ore mineralizations such as gold and other hydrothermal deposits like Ag, Hg, Sb, As,Cu, Ni, Co, as well as magnesite and talc.

52 **Diamond In kimberlite and corundum In nepheline syenlte are good examples of**

A.	Disseminated deposit	**C.**	Injected deposit
B.	Segregated deposit.	**D.**	Pegmatitic deposit.

53 **Kaolin adsorbs copper from solution to form :**

A.	Azurite	**C.**	Chrysocolla
B.	Chalcoclte.	**D.**	Atacamite

54 **The formation temperature of different magmatic deposits varies from :**

A.	2000° to 500 °c.	**C.**	1000°c to 2oo°
B.	1500°c to 300°c.	**D.**	800°c to 100°c.

55 **Magmatic magnetite deposits occur with :**

A.	High viscosity.	**C.**	Syenite
B.	Diorite	**D.**	Pegmatite

56 **Platinum occurs only with :**

A.	Mafic rocks	**C.**	Mafic to rocks
B.	Ultramafic rocks	**D.**	Mafic to Ultrabasic rocks

57 **The metasomatic deposits are usually resulted in :**

A.	Calcareous rocks	**C.**	Ferruginous rocks
B.	Arenaceous rocks.	**D.**	Siliceous rocks.

58 **An assemblage ot high temperature metamorphic gangue minerals in contact metasomatic deposits is called :**

A.	Skarn.	**C.**	Gossans
B.	Gondite	**D.**	Bar deposits

59 **Generally tourmaline-rich rocks are products of :**

A.	Metamorphism	**C.**	Metasomatism
B.	Magmatic crystallisation	**D.**	Oxidation and supergene enrichment

60 **Hydrothermal deposits, which are formed at great depths, near the intrusive and within the Temperature range of 300°c to 500°c is called:**

A.	Hypothermal deposits	**C.**	Epithermal deposits
B.	Ultramafic rocks	**D.**	Syngenetic deposits.

61 **Of the following ratios, the one which would NOT be useful as the basis for a method for dating igneous rocks over 1,000,000 years old is :**

A.	Uranium ^{238} / Lead ^{206}	**C.**	Carbon 14 / Carbon 12
B.	Rubidium ^{87} / Strontium ^{87}	**D.**	Potassium ^{40} / Argon ^{40}

62 **In the case of chemical precipitation from carbonate solutions, the separation of Monroe from Fe occurs because:**

(a) Mn carbonate is more soluble in solution than Fe carbonate.
(b) Mn carbonate is more stable in solution than Fe carbonate.
(c) Both Mn and Fe carbonates are not soluble in solution.
(d) None of these.

63 **Under which environment both Iron and manganese may precipitate together as Carbonates:**

A.	Oxidizing environment	**C.**	Neutral environment
B.	Reducing environment	**D.**	Both (a) and (b).

64 **Dilation or Lenticular vein are generally associated with:**

A.	Granites	**C.**	Basalts
B.	Schists	**D.**	Marbles

65 **When copper ores occupying sandstone pores then it is known as:**

A.	Sandy ores	**C.**	Pore ores
B.	Sandstone copper ores	**D.**	Red beds ores

66 **Metasomatic replacement deposits are characterized by:**

(a) Preservation of rock structure.
(b) Presence of pseudo morphs of replacing minerals after the replaced one.
(C) Absence of Crusification.
(d) All the above.

67 **Ore shoots are most characteristic of:**

A.	Fissure veins only	**C.**	Replacement loads only
B.	Fissure veins and replacement loads	**D.**	Breccia-filling deposits.

68 **An exceptionally rich shoot or bunch of ore is called:**

A.	Bonanza	**C.**	Flake
B.	Chimneys	**D.**	Pitch

69 **Most of metal enrichments result due to:**

A.	Removal of the gangue components	**C.**	Chemical migration
B.	Redeposit ion.	**D.**	All the above

70 **Mark the correct statement regarding deposition of pyrite:**

(a) lt is deposited in a reducing environment.
(b) lt is deposited under both acid and alkaline condition,
(c) It is deposited in oxidizing environment under both acid and alkaline conditions.
(d) lt is deposited in a reducing environment under both acid and alkaline conditions.

71 **Iron is commonly precipitated as :**

A.	Siderite	**C.**	Hematite
B.	Limonite	**D.**	All the above are correct.

72 **Which of the following is the most accurate explanation for the occurrence of minerals such as gold, platinum, and native copper in concentrated placer deposits in alluvial sands and gravels?**

A. These minerals are more resistant to chemical weathering than the surrounding matrix and are left behind when natural acids in streams erode the matrix away.
B. These minerals commonly occur as smaller grains than most other minerals and are carried farther by flowing water before settling to the bottom of the stream.
C. These minerals are characterized by irregularly shaped grains that tend to interlock and form a large mass that resists displacement by moving water.
D. These minerals have a higher specific gravity than most other minerals and are deposited more quickly than particles of similar size when stream velocity decreases.

73 **A metal that occurs in placer deposits is**

A.	Gold	**C.**	Hematite
B.	Limonite	**D.**	Zinc

74 **What is the mineral which contains a metallic element which can be economically exploited called?**

A.	Ore mineral	**C.**	Eco-ore
B.	Metallic mineral	**D.**	Eco-mineral

75 **The definition of ore is dependent on _____**

A.	Quantity	**C.**	Color
B.	Size	**D.**	Quality

76 **The non-metallic minerals associated with ore minerals are called _____**

A.	Non-metallic minerals	**C.**	Gangue minerals
B.	Metallic minerals	**D.**	Flux minerals

77 **How many types of rocks are there on the basis of time of formation?**

A.	1	**C.**	3
B.	2	**D.**	4

78 **Cavities in the vein left untilled are called:**

A.	Crusification	C.	Comb structure
B.	Bugs	D.	None of these

79 **The deposits that have formed simultaneously with the enclosing rock are called**

A.	Syngenetic	C.	Syncgenetic
B.	Epigenetic	D.	Sinclogenetic

80 **Deposits that were formed subsequent to the formation of the host rocks are called**

A.	Syngenetic	C.	Syncgenetic
B.	Epigenetic	D.	Sinclogenetic

81 **Which of the following is not an essential condition for hydrothermal deposits?**

A.	Highly active fluids	C.	Highly inactive fluids
B.	Highly enriched fluids	D.	Suitable pathways

82 **Type of veins which are bodies of tubular shape in pre-existing fissures?**

A.	Fissure-veins	C.	Gash-veins
B.	Ladder-veins	D.	Stock works

83 **The type of vein commonly found in igneous rocks is _____**

A.	Fissure-veins	C.	Gash-veins
B.	Ladder-veins	D.	Stock works

84 **Gash-veins are generally found in _____**

A.	Silicate minerals	C.	Metallic minerals
B.	Felspar minerals	D.	Carbonate minerals

85 **When gravity is the agent of placing of deposit, the deposit is called**

A.	Deluvial deposit	C.	Alluvial deposit
B.	Aeolian deposit	D.	Beach placers

86 **What are the estimated temperatures and depths ranges of hydro-thermal ore**

Epithermal	50-200 °C, typically in depths < 1500 m
Mesothermal	200-400 °C , 1500-4500 m
Hypothermal	400-600 °C , >4500 m

87 **The term used for the rock hydrothermal deposits that occur in veins of exceptionally small size, but in good number is _____**

A.	Fissure-veins	**C.**	Gash-veins
B.	Ladder-veins	**D.**	Stock works

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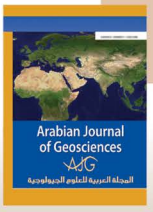
Prof. Abdullah M. Al-Amri

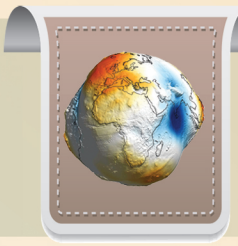
www.alamrigeo.com E.mail : alamri.geo@gmail.com Cell : +966505481215

Qualifications & Experiences	❖ Professor of Geophysics at King Saud Univ. My research interests are in the area of crustal structures and seismic micro zoning of the Arabian Peninsula. My recent projects involve also applications of EM and MT in deep groundwater exploration and geothermal prospecting. ❖ PhD in Geophysics (1990) from the University of Minnesota, USA ❖ Supervisor of the Seismic Studies Center, KSU. ❖ Supervisor of the Groundwater Exploration Chair at KSU. ❖ Supervisor of the Geothermal Energy Center at KSU. ❖ President of the Saudi Society for Geosciences. ❖ Head of the Department of Geology & Geophysics, KSU. ❖ Founder & Editor-in-Chief of the Arabian Journal of Geosciences (AJGS). ❖ Team Leader of the Scientist Fellowship Program with Oregon State University, USA. ❖ Team Leader of the Scientist Fellowship Program with Max Planck Institute, Germany.
Consultancies & Memberships	❖ Consultant of King Abdulaziz City for Science and Technology. ❖ Consultant of the Saudi Geological Survey ❖ Consultant of Military Survey & Civil Defense ❖ Advisor to King Abdullah City for Atomic and Renewable Energy. ❖ Advisor to the Nuclear and Radiological Resources Authority. ❖ Principal researcher in several research projects supported by King KACST & Aramco. ❖ Principal researcher in projects supported by the US Department of Energy, the University of California, Lawrence Livermore National Lab., Universities of Alabama, PSU, OSU, USA ❖ Member of the American Seismological Society. ❖ Member of the American Geophysical Union. ❖ Member of the European Union of Geologists and Engineers. ❖ Member of the Saudi Building Code Committee. ❖ Member of the Gulf Seismic Forum (GSF). ❖ Member of the Earthquake Risk Mitigation Committee of the Eastern Mediterranean Countries (RELEMR) ❖ Among the list of outstanding Arab achievers by Rivacimento International. ❖ Among the Who's Who in Asia for Scientific Excellence. ❖ On the Who's Who in the World List of Scientific Contributions.
Scientific Publication	❖ Published more than **200** scientific papers in peer-reviewed journals ❖ Authored **35** scientific books ❖ issued a digital encyclopedia of earth sciences of **14** volumes and **107** scientific files.
Projects	❖ Completed **40** local projects, **16** international projects and **74** technical reports.
Conferences	❖ Participated in more than **125** local and international conferences & **75** specialized seminars and workshops
International Cooperation	❖ Principal researcher in **13** American and German working groups.
Prizes	❖ Received Almarai Prize for Scientific Creativity in 2005. ❖ Received the Golden Excellence Award from KACST in 2006. ❖ Received Abha Appreciation Award for Scientific Contributions in 2007. ❖ Received King Saud University Award for Scientific Excellence in 2013. ❖ Received the American Geophysical Union Award for International Cooperation and Research Activities in 2013. ❖ Received the Sultan Qaboos University Award for Scientific Contributions in 2013. ❖ Received the King Saud Prize for inclusion of the Arab Journal of Geological Sciences in the ISI list. ❖ Received the award for the best editor-in-chief of the scientific journal of the year 2017 & 2018 from the German publisher Springer. ❖ Recipient of the 2018 Albert Nelson Marquis Lifetime Achievement Award from Who's Who ❖ Received **85** honorary shields and certificates of appreciation from Saudi Arabia, Oman, Kuwait, UAE, Jordan, Egypt, Tunisia Algeria, Germany and America



موسوعة العمري في علوم الأرض

Al-Amri's Encyclopedia of Earth Sciences



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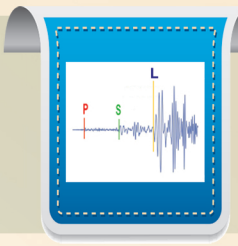
2 شكل الأرض وحركاتها

3 الجاذبية الأرضية وتطبيقاتها

4 التركيب الداخلي للأرض

5 المعادن والتعدين

6 المد والجزر



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8 الزلازل والتفجيرات

9 تقييم مخاطر الزلازل

10 البراكين وسبل مجابهتها

11 جيولوجية القمر

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