E-PG PATHSHALA IN EARTH SCIENCE

Content Writers Template

1. Details of Module and its Structure

Module details	
Subject Name	Earth Science
Paper Name	**Sedimentology & stratigraphy**
Module Name/Title	**Depositional environments**
Module Id	ES07-268
Pre-requisites	Before learning this module, the users should be aware of • Physical features of the earth • Sedimentology and its parameters • Process of sedimentation • Environment in sedimentation
Objectives	The objectives of learning this module are to understand • To understand the sedimentation clues with defined environment • To decipher the depositional process and system • To the depositional environment through geological period is a tool to evaluate the exportability of resources withy time and space
Keywords	Depositional environments – Continental – Transitional – Marine - Sedimentary facies and Sedimentary structures

2. Structure of the Module-as Outline : Table of Contents only (topics covered with their sub-topics)

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3. Development Team

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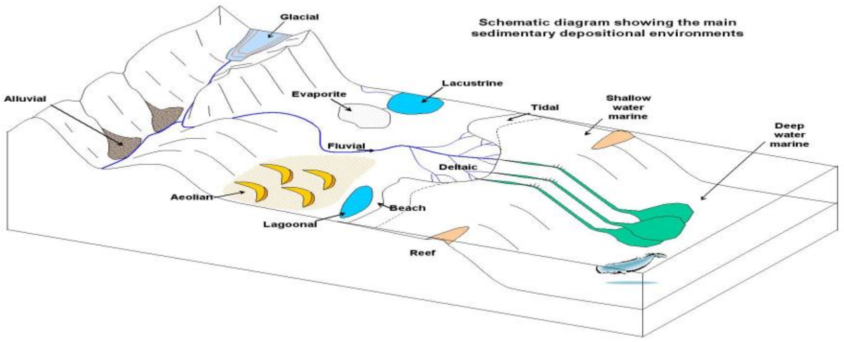
4. E-text (as per table of contents)

Headings	Sub-headings with para-wise contents

1.0 Introduction

Depositional environments are those sediment accumulate in some environment of deposition which describes the combination of physical, chemical and biological processes associated with the deposition of a particular type of sediment. Depositional environments may be distinguished from erosion environments, in which erosion of the Earth's surface is taking place. Both depositional and erosion environments are of interest to understand the origin of sedimentary rocks.



2.0 **Importance of depositional environments**

By reconstructing depositional environments geologists are able to reconstruct the climates of the past, life forms of the past, and geography of the past-where the mountains, basins, large rivers, and bays of the ocean formation. It attributes for sedimentary basin analysis to assess in potentiality for exploration and to correlate the geological events, process and environment

2.1 **Sedimentary Environment (Process Element)** → **Sedimentary Facies (Response Element)**

Sedimentary Environment (Process Element)

Dynamic elements of the environment

- Physical processes: wave and current activity; gravity processes; sea-level changes; tectonism and volcanism
- Chemical processes: solution, precipitation, authigenesis
- Biological processes: biochemical precipitation; biologic reworking of sediment; photosynthesis

Static elements of the environment

- Geomorphology of the depositional site
- Water depth
- Water chemistry
- Depositional materials (sediment supply)
- Climate

Sedimentary Facies (Response Element)

Geometry of the deposit

- Blanket, prism, shoestring, etc.

Primary sediment properties

- Physical: bedding and contact relationships; sedimentary textures and structures; color; particle composition
- Chemical: major-element and trace-element composition
- Biological: fossil content (types and abundances of fossils)

Derived sediment properties

- Porosity and permeability
- Accoustical properties (sound transmissibility)
- Electrical conductivity
- Radioactivity

2.2 **Factors control depositional environment:**

The major factor affecting the nature and distribution of sedimentary environments is the overall structural development, or tectonics, of the area. Tectonics determines the major geological structure or setting of an environment of deposition, including the location and nature of the main areas undergoing uplift or subsidence. Areas with high relief, such as mountains and volcanoes, suffer rapid erosion and supply much more sediment to basins of deposition than larger areas of low relief.

The physical, chemical and biological characteristics (parameters), which vary from place to place accordingly the deposition of sediment varies.

- The physical parameters of sedimentary environments include the velocity, direction and variation of wind, wave and flowing water. It is include the climate (temperature, snowfall, rainfall and humidity) and weather of the environments.
- The chemical parameters of an environment include the composition of waters which cover a subaqueous sedimentary environment. They also include the geochemistry of the rocks in the catchment area of a terrestrial environment.
- The biological parameters comprise both fauna and flora. On land these may have major effects on sedimentary processes. The flora and fauna in marine environment, are important because their presence in water can change its equilibrium, and resulting in the precipitation of chemical sediments.

3.0 **Types of depositional environment**:

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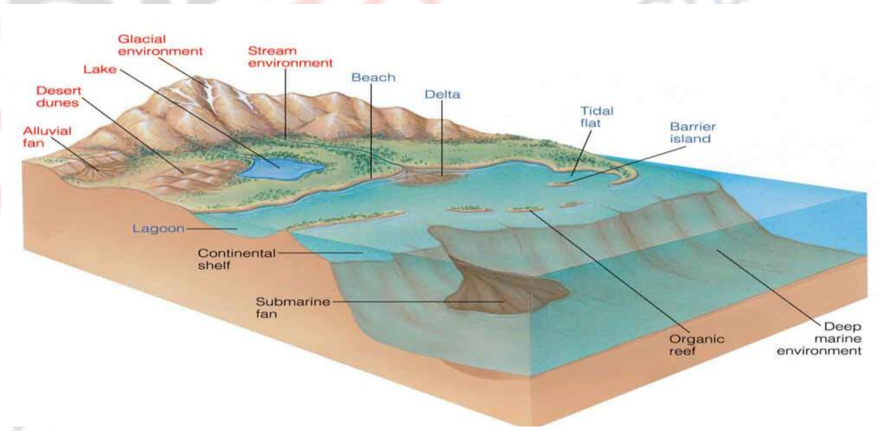
Depositional environments classified into three categories:

- Terrestrial, including alluvial fans, fluvial plains, sandy deserts, lakes, and glacial regions. Dominated by the process of erosion, transport and deposition:
- Mixed/Transitional (shore-related), including deltas, estuaries, barrier island complexes, and glacial marine environments. Dominated by the process of transport and deposition;
- Marine, including terrigenous shelves or shallow seas, carbonate shelves or platforms, continental slopes, continental rises, basin plains, ocean ridges, and ocean trenches. Dominated by the process of transport and deposition

Although the importance of tectonics and climate in controlling sedimentary environments is widely recognized, most classifications are based mainly on topography.

Classification of ancient depositional environments

Primary Depositional Setting	Major Environment	Subenvironment
Continental	*Fluvial	*Alluvial fan *Braided stream *Meandering stream
	*Desert Lacustrine *Glacial	
	*Deltaic	*Delta plain *Delta front *Prodelta
Marginal-marine		
	*Beach/barrier island *Estaurine/lagoonal Tidal flat	
	Neritic	Continental shelf **Organic reef
Marine		
	Oceanic	Continental slope Deep-ocean floor



3.1 **Continental sedimentary environments**

Continental	**Alluvial fan**	**Fluvial**	**Lacustrine**	**Desert (dunes)**	**Paludal**
Rock Type	Breccia, conglomerate, arkose	Conglomerate, sandstone, siltstone, shale	Siltstone, shale, limestone, or evaporites (gypsum)	Quartz arenite (sandstone) or gypsum	Peat, coal, black shale, siltstone
Composition	Terrigenous	Terrigenous	Terrigenous, carbonate, or evaporite	Terrigenous or evaporite	Terrigenous
Colour	Brown or red	Brown or red	Black, brown, gray, green	Yellow, red, tan, white	Black, gray, or brown
Grain Size	Clay to gravel	Clay to gravel (Fining upward)	Clay to silt or sand (Coarsening upward)	Sand	Clay to silt
Grain Shape	Angular	Rounded to angular	---	Rounded	---
Sorting	Poor	Variable	Variable	Good	Variable
Inorganic Sedimentary Structures	Cross-bedding and graded bedding	Asymmetrical ripples, cross-bedding, graded bedding, tool marks	Symmetrical ripples, lamination, cross-bedding, graded bedding, mud cracks, raindrop prints	Cross-bedding	Laminated to massive
Organic or Biogenic Sedimentary Structures	---	Tracks, trails, burrows	Tracks, trails, burrows, rare stromatolites	Tracks, trails	Root marks, burrows
Fossils	---	Rare freshwater shells, bones, plant fragments	Freshwater shells, fish, bones, plant fragments	---	Plant fossils, rare freshwater shells, bones

Continental

Alluvial

Alluvium (from the Latin, alluvius, from alluere, "to wash against") is loose, unconsolidated (not cemented together into a solid rock) soil or sediments, which has been eroded, reshaped by water in some form, and redeposited in a non-marine setting. Alluvium is typically made up of a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel. When this loose alluvial material is deposited or cemented into a lithological unit or lithified, it would be called an alluvial deposit. Most, if not all, alluvium is very young (Quaternary in age), and is often referred to as "cover" because these sediments obscure the underlying bedrock. Most sedimentary material that fills a basin ("basin fills") that is not lithified is typically lumped together in the term alluvial. Alluvium can contain many valuable ores such as gold and platinum and a wide variety of gemstones. Such concentrations of valuable ores are termed a placer deposit.

Aeolian

Aeolian processes, also spelled eolian, or æolian, pertain to wind activity in the study of geology and weather, and specifically to the wind's ability to shape the surface of the Earth (or other planets). Winds may erode, transport, and deposit materials, and are effective agents in regions with sparse vegetation and a large supply of unconsolidated sediments. Although water is a much more powerful eroding force than wind, aeolian processes are important in arid environments such as deserts. The term is derived from the name of the Greek god, Æolus, the keeper of the winds.

Fluvial

Fluvial is a term used in geography and Earth science to refer to the processes associated with rivers and streams and the deposits and landforms created by them. When the stream or rivers are associated with glaciers, ice sheets, or ice caps, the term glaciofluvial or fluvioglacial is used. Fluvial processes include the motion of sediment and erosion or deposition on the river bed. Erosion by moving water can happen in two ways. Firstly, the movement of water across the bed exerts a shear stress directly onto the bed. If the cohesive strength of the substrate is lower than the shear exerted, or the bed is composed of loose sediment which can be mobilized by such stresses, then the bed will be lowered purely by clearwater flow. However, if the river carries significant quantities of sediment, this material can act as tools to enhance wear of the bed (abrasion). At the same time the fragments themselves are ground down, becoming smaller and more rounded (attrition).Sediment in rivers is transported as either bed load (the coarser fragments which move close to the bed) or suspended load (finer fragments carried in the water). There is also a component carried as dissolved material.

Lacustrine

A lake is a body of relatively still liquid (prototypically water) of considerable size, localized in a basin, that is surrounded by land apart from a river or other outlet that serves to feed or drain the lake. Lakes lie on land and are not part of the ocean, and therefore are distinct from lagoons, and are also larger and deeper than ponds. Lakes can be contrasted with rivers or streams, which are usually flowing. However most lakes are fed and drained by rivers and streams.

Paludal

(swamps and marshes)- organic-rich shale and sandstone or coal deposits with thin stringers of siltstone and shale. Plant fossils are common in all stages of preservation.

Eolian

(deserts and near beaches) - recognized by dune deposits, although the dominant sedimentary layering that is preserved is horizontal.

3.2 **Transitional sedimentary environments**

Transitional	**Delta**	**Barrier beach**	**Lagoon**	**Tidal flat**
Rock Type	Sandstone, siltstone, shale, coal	Quartz arenite, coquina	Siltstone, shale, limestone, oolitic limestone or gypsum	Siltstone, shale, calcilutite, dolostone or gypsum
Composition	Terrigenous	Terrigenous or carbonate	Terrigenous, carbonate, or evaporite	Terrigenous, carbonate, or evaporite
Color	Brown, black, gray, green, red	White to tan	Dark gray to black	Gray, brown, tan
Grain Size	Clay to sand (Coarsening upward	Sand	Clay to silt	Clay to silt
Grain Shape	---	Rounded to angular	---	---
Sorting	Poor	Good	Poor	Variable
Inorganic Sedimentary Structures	Cross-bedding, graded bedding	Cross-bedding, symmetrical ripples	Lamination, ripples, cross-bedding	Lamination, mud cracks, ripples, cross-bedding
Organic or Biogenic Sedimentary Structures	Trails, burrows	Tracks, trails, burrows	Trails, burrows	Stromatolites, trails, tracks, burrows
Fossils	Plant fragments, shells	Marine shells	Marine shells	Marine shells

Deltaic

A river delta is a landform that is formed at the mouth of a river, where the river flows into an ocean, sea, estuary, lake, or reservoir. Deltas are formed from the deposition of the sediment carried by the river as the flow leaves the mouth of the river. Over long periods of time, this deposition builds the characteristic geographic pattern of a river delta. River deltas form when a river carrying sediment reaches either (1) a body of standing water, such as a lake, ocean, or reservoir, (2) another river that cannot remove the sediment quickly enough to stop delta formation, or (3) an inland region where the water spreads out and deposits sediments.

Types of deltas

Deltas are typically classified according to the control on deposition, which is usually a river, waves, or tides. These controls have a large effect on the shape of the resulting delta. Wave-dominated deltas, Tide-dominated deltas, Gilbert deltas, Estuaries, Inland deltas.

Tidal

Tides are the rise and fall of sea levels caused by the combined effects of the gravitational forces exerted by the Moon and the Sun and the rotation of the Earth. Some shorelines experience two almost equal high tides and two low tides each day, called a semi-diurnal tide. Some locations experience only one high and one low tide each day, called a diurnal tide. Some locations experience two uneven tides a day, or sometimes one high and one low each day; this is called a mixed tide. The times and amplitude of the tides at a locale are influenced by the alignment of the Sun and Moon, by the pattern of tides in the deep ocean, by the amphidromic systems of the oceans, and by the shape of the coastline and near-shore bathymetry.

Lagoon

Lagoons are shallow, often elongated bodies of water separated from a larger body of water by a shallow or exposed shoal, coral reef, or similar feature.

Beach

A beach is a landform along the shoreline of an ocean, sea, lake, or river. It usually consists of loose particles, which are often composed of rock, such as sand, gravel, shingle, pebbles, or cobblestones. The particles comprising the beach are occasionally biological in origin, such as mollusc shells or coralline algae.

3.3 M**arine sedimentary environments**

Marine	**Reef**	**Continental shelf**	**Continental slope and rise**	**Abyssal plain**
Rock Type	Fossiliferous limestone	Sandstone, shale, siltstone, fossiliferous limestone, oolitic limestone	Litharenite, siltstone, and shale (or limestone)	Shale, chert, micrite, chalk, diatomite
Composition	Carbonate	Terrigenous or carbonate	Terrigenous or carbonate	Terrigenous or carbonate
Color	Gray to white	Gray to brown	Gray, green, brown	Black, white red
Grain Size	Variable, frameworks, few to no grains	Clay to sand	Clay to sand	Clay
Grain Shape	---	---	---	---
Sorting	---	Poor to good	Poor	Good
Inorganic Sedimentary Structures	---	Lamination, cross-bedding	Graded bedding, cross-bedding, lamination, flute marks, tool marks (turbidites)	Lamination
Organic or Biogenic Sedimentary Structures	---	Trails, burrows	Trails, burrows	Trails, burrows
Fossils	Corals, marine shells	Marine shells	Marine shells, rare plant fragments	Marine shells (mostly microscopic)

Shallow water marine environment: Shallow water marine environment refer to the area between the shore and the beginning of the reef wall. This environment is host to many organisms that leave their trace in the form of ooids, trace fossils, bore holes and many other ways. The vast majority of the fossil record has been found after the shallow water marine environment has been lithified. Many of these fossils were deposited at times when much of Earth was covered with shallow seas, supporting a wide variety of organisms and other living creatures. The sediment itself is often composed of limestone, which forms readily in shallow, warm calm waters. The shallow marine environments are not exclusively composed of siliciclastic or carbonaceous sediments. While they cannot always coexist, it is possible to have a shallow marine environment composed solely of carbonaceous sediment or one that is composed completely of siliciclastic sediment. Shallow water marine sediment is made up of smaller grain sizes, because these smaller grains have been washed out of higher energy areas.

Deep water marine environment

A. Pelagic - fine-grained sediments deposited far from land influence by slowly settling particles suspended in the water column.

1. Carbonate ooze - carbonate shells of tiny planktonic organisms (foraminifera, coccolithoforids)
2. Silica ooze - silica shells of tiny planktonic organisms (radiolarian, diatoms)
3. Red clay - clay-sized particles of continental origin (mostly transported by wind). Very high Fe and Mn contents produce the coloration, and frequently Mn pavements, crusts and nodules are found in this environment.

B. Turbidites - fining-upward deposits that were transported seaward in deep-sea channels and canyons by high-density, sediment laden currents. In map view, turbidites form fans that spread outward on the sea floor from the mouths of the canyons.

Reef

A reef is a rock, sandbar, or other feature lying beneath the surface of the water (80 meters or less beneath low water).Many reefs result from abiotic processes-deposition of sand, wave erosion planning down rock outcrops, and other natural processes-but the best-known reefs are the coral reefs of tropical waters developed through biotic processes dominated by corals and calcareous algae.

3.4 **Evaporites**

Evaporites is a name for water-soluble mineral sediment that results from concentration and crystallization by evaporation from an aqueous solution. There are two types of evaporate deposits: marine, described as ocean deposits, and non-marine; formed in lakes.

Glacial

A glacial period (or alternatively glacial or glaciations) is an interval of time (thousands of years) within an ice age that is marked by colder temperatures and glacier advances. Interglacial, on the other hand, are periods of warmer climate between glacial periods. The last glacial period ended about 15,000 years ago; The Holocene epoch is the current interglacial.

4.0 **Recognition of depositional environments in ancient sediments:**

Depositional environments in ancient sediments are recognised using a combination of sedimentary facies, facies associations, sedimentary structures and fossils, particularly trace fossil assemblages, as they indicate the environment in which they lived.

Environmental analysis thus involves identifying response elements or properties that have environmental significance. These properties include (it means that depositional environments in ancient sediments are recognized using a combination of)

a) sedimentary structures and textures (which reflect depositional processes such as current flow and suspension settling of grains),

b) sedimentary facies associations (such as fining and coarsening-upward successions of facies, which indicate shifts in environmental conditions), and

c) Fossils (which are useful indicators of salinity, temperature, water depths and energy, and turbidity of ancient oceans) and trace fossil assemblages. These properties can be used to construct facies models for each major depositional environment. A facies model is a general summary of the characteristics of a given depositional system.

4.1 **Sedimentary facies**

A characteristic association of sedimentary rock features linked to a distinct sedimentary environment. In a given location, one sedimentary facies tends to grade laterally into others. Sedimentary facies are bodies of sediment recognizably different from adjacent sediment deposited in a different depositional environment.

Generally, facies are distinguished by what aspect of the rock or sediment is being studied. Thus, facies based on petrological characters such as grain size and mineralogy are called lithofacies, whereas facies based on fossil content are called *biofacies*. These facies types are usually further subdivided, for example, you might refer to a "tan, cross-bedded oolitic limestone facies" or a "shale facies". The characteristics of the rock unit come from the depositional environment and original composition. Sedimentary facies reflect depositional environment, each facies being a distinct kind of sediment for that area or environment. Since its inception, the facies concept has been extended to related geological concepts. For example, characteristic associations of organic microfossils, and particulate organic material, in rocks or sediments, are called palynofacies. Discrete seismic units are similarly referred to as seismic facies.

4.2 **Walther's Law**

Walther's Law of Facies, states that the vertical succession of facies reflects lateral changes in environment. Conversely, it states that when a depositional environment "migrates" laterally, sediments of one depositional environment come to lie on top of another. A classic example of this law is the vertical stratigraphic succession that typifies marine transgressions and regressions.

5.0 **Sedimentary structures:** The second key to the identification of sedimentary facies and environments is small scale physical features..

Stratification - layering / bedding -individual layers are called strata (sing. stratum) or beds are lain down parallel, with younger beds on top of older ones (superposition)

Cross bedding:- Beds (parallel to each other) aligned at an angle to the surface upon which they accumulated -result of deposition of dunes or ripples.

Graded bedding: As current slows down it drops the largest particles first and smallest particles last, resulting in a stratum with the largest clasts on the bottom followed by smaller particles.

6.0 **Sedimentary texture** Grain size data of limited usefulness; grain shape measured by fourier analysis may be significant; grain orientation a useful paleocurrent indicator

7.0 **Surface features:**

Ripples: Formed by movement of a current over loose sand to clay sized sediment. Ripples formed by waves have a symmetrical cross section. Those formed by a stream current are asymmetrical.

Rain drop prints

Mud cracks

Tool marks: Formed when the current carries an object across the sediment.

Sole marks: Formed on the under surface of a bed that conforms acts as a mould for the surface on which it is deposited.

8.0 **Energy in the depositional environment:**

The identification of sedimentary facies and environments is the relationship between energy and clast size. The smaller the dominant clasts, the lower the energy of the depositional environment.

9.0 **Depositional Environments of Sandstone**

Sand forms sandstones which occurs in beaches and deserts. Differentiation of sandstone deposited in a beach or desert environment by studying the layering in the rock to mimics the pattern of sand dunes alone (desert) or whether there are signs of water deposition, such as preserved ripple marks, flat layers representing the swash zone of a beach (the place where the waves come onto the beach and flatten the sand out) or evidence of waves from large storms moving the sand underwater.

10.0 **Depositional Environments for Shale**

Shale is a rock that comes from relatively deep, calm water. Because shale is made of very small particles (fine sediments), it must be deposited in water that is calm enough to no longer suspend such fine particles.

11.0 **Depositional Environments for Limestone**

One place where limestone deposits are found is in very deep ocean water. Way out in the ocean, where the water is calm & deep, live multitudes of tiny marine animals. These animals use the calcium carbonate in sea water to make their shells. When these animals die, they fall to the sea floor. Over millions of years, the shells accumulate, & are eventually buried, cemented & turned into limestone. It is not common to find large fossils in deep-water limestone. Limestones form when the concentration of calcite increases to the point where the molecules start to fall out of the water. Another environment that creates carbonate deposits is a coral reef. Reefs are composed of almost 100% calcium carbonate. Reefs distribution is in shallow marine water.

12.0 **Depositional Environment for Conglomerate** Conglomerate rocks have spaces between the rocks filled in with a matrix cement, like concrete. A common place to find conglomerate is near a river. Rivers, because they move at different velocities, are able to transport and deposit rocks of all different sizes. If the river flowed at a constant velocity it would have about the same sized rock throughout. In places along the river the where the rate of flow slows, there you will find rocks surrounded by a matrix mud
13.0 **Trace fossils** Trace fossils, also called ichnofossils are geological records of biological activity. Trace fossils may be impressions made on the substrate by an organism: for example, burrows borings (bio-erosion), urolites (erosion caused by evacuation of liquid wastes), footprints and feeding marks, and root cavities. The term in its broadest sense also includes the remains of other organic material produced by an organism - for example coprolites (fossilized droppings) or chemical markers or sedimentological structures produced by biological means - for example, Stromatolites. Trace fossils contrast with body fossils, which are the fossilized remains of parts of organisms' bodies, usually altered by later chemical activity or mineralization. Trace fossils are generally difficult or impossible to assign to a specific maker. Only in very rare occasions are the makers found in association with their tracks. Further, entirely different organisms may produce identical tracks. Five behavioral modes are recognized: Domichnia, dwelling structures reflecting the life position of the organism that created it. Fodinichnia, three-dimensional structures left by animals which eat their way through sediment, such as deposit feeders; **Pascichnia**, feeding traces left by grazers on the surface of a soft sediment or a mineral substrate; **Cubichnia,** resting traces, in the form of an impression left by an organism on a soft sediment; **Repichnia,** surface traces of creeping and crawling. Fossils are further classified into form genera, a few of which are even subdivided to a "species" level. Classification is based on shape, form, and implied behavioral mode.

14.0 E**xamples of sediments and their particular depositional environments**

Turbidities: The oceans receive most of the clastic sediments that erode from the continents. On the edges of the continental shelves, where the submarine slope tilts down into much deeper water, accumulations of mud and sand deposited by rivers build up. Eventually, sediment builds up on the edge of the steepening slope that it is likely to give way into an underwater landslide. The submarine landslide will flow down the slope into deeper water, mixing with seawater as it goes to form what is called a turbidity current. As the sediments gradually settle out of the turbidity current onto the deeper ocean floor, the coarser grained sediments (those sediment grains with larger diameters) will settle to the bottom first, followed gradually by finer and finer sediments. This creates a graded sequence of sediments-it grades upward from a bed of sand through a layer of silt to a top layer of fine mud. This graded deposit becomes a rock known as turbidities. Over the years a turbidities is likely to be deposited on top of another, over and over again thousands of times. This creates repeated beds of coarse sand to fine mud, which may total sands of feet thick.

Varves: Varves are annual layers of sediment, layers of sediment that accumulate each year, year after year. Varves are deposited as rhythmic beds, beds laid down in a repeating pattern. A common depositional environment in which one type of varves is deposited is lakes in cold climates where the surface of the lake freezes every winter and thaws every spring and summer. During the spring/summer thaw, streams discharge at a high rate into the lake, causing the deposition of a layer of silt on the bed of the lake. The silt is usually rich in quartz and feldspar and light-colored. During the winter freeze, when there is little or no stream-borne sediment coming into the lake, only clay-size particles settle to the bottom of the lake, along with any planktonic (floating, mostly microscopic) organisms that flourished in the summer and died as the lake froze. The winter sediment is thus clay, sometimes dark clay due to having a small amount of carbon in it. The resulting varve is a pair of strata: a light-colored stratum of silt from the spring-summer warm season, and a darker stratum of clay from the winter freeze. Sequences of varves are especially common in locations that were the beds of lakes near glaciers during ice ages. Ice ages are times when continental glaciers formed and advanced outside of polar regions. The most recent ice age, the Pleistocene epoch (approximately 2.5 million to 12,000 years ago), saw continental glaciers advance several times in northern North America (into what is now the northern-most United States), the Scandinavian Peninsula and nearby parts of Europe including Britain, and parts of northern Asia. During continental glaciations, the glaciers dammed many stream drainages and created temporary lakes in cold climates next to the glaciers, where sequences of varves accumulated.

Marine Limestone: Limestone, rock made of the calcium carbonate mineral known as calcite, can form in a variety of depositional environments, from hot spring deposits in lakes to coral reefs in the tropical oceans. Most limestone originates in shallow waters of tropical oceans, and may carry fossils of plants and animals that lived in those marine environments. However, limestone's made of buried coral reefs are not as common as limestone made simply from lime mud. Lime mud originates from disintegrated organisms that have hard parts made of calcium carbonate. As a result, limestone is commonly massive (lacks obvious beds), fine-grained, and lacks obvious fossils.

Tsunami Deposits: When devastating subduction zone earthquakes occur along a coast, extremely large water waves called tsunamis are generated. At the same time, sea level changes relative to land level along the local shore. The combination of a sudden drop in land level and a tsunami washing over coastal lowlands creates several distinctive markers in the sediment layers that remain. These include muddy coastal marsh deposits overlain by gravel or sand deposits that have sedimentary structures indicating high-energy waves flowed inland along the coast. Where the coast is nearly flat rather than steep, these tsunami deposits can extend miles inland.

Coal: Coal is a chemical sedimentary rock made of carbon. It forms from the remains of plants that lived in moist environments rich in trees, shrubs, water, and mud. In such swampy settings, the dead plant debris is quickly buried and thus escapes rotting away at the earth's surface. Upon being buried, heated and compressed within the earth's crust, the dead plants will become coal if the right conditions of heat and pressure are achieved.

Meandering Rivers: Sequences of beds of sandstone, conglomerate, siltstone, shale, and plant fossils indicate sediment deposition by a system of meandering rivers. If there were thick woods and densely vegetated swampy areas, there may also be coal. Details in the sedimentary structures, characteristic signatures of particular depositional processes, will confirm if there were meandering river channels, sandbars, stream bank erosion, and occasional floods.