Q & A

Q. What is the hypothesis of continental drift?

- That there was a supercontinent called Pangaea that began to break apart about 200 Ma, this was proposed by Alfred Wegener in 1912.

Q. What are the evidences that used to support this hypothesis?

- Fit of the continents, fossil evidence, rock type and structural similarities, and Paleoclimatic evidence.

Q. What does Holmes proposed in 1927?

- He proposed the mechanism for movement of continents by convection currents powered by heat. Convection is heat transfer and mass transfer. Increase temperature, reduce density, plate will sink. Upper layer has high density.

Q. What is seafloor spreading hypothesis?

- Seafloor spreading hypothesis was proposed in 1961 by Dietz. He suggested that upwelling of mantle material along mid-ocean ridges create new seafloor. At subduction zones old seafloor descends into the mantle.

Q. What does ocean floor behaves like?

- Ocean floor behaves like a magnetic recorder. Magma cools down; where downward magnetic is positive and upward magnetic is negative.

Q. What is Paleomagnetism?

- Paleomagnetism is the past magnetism recorded in the rocks. It was the most convincing evidence to support the concepts of contintal drift and seafloor spreading.

Q. What are earth's main and minor plates?

- Earth has 7 major and several small plates. They are:

1. African Plate covering Africa - Continental plate
2. Antarctic Plate covering Antarctica - Continental plate
3. Australian Plate covering Australia - Continental plate
4. Indian Plate covering Indian subcontinent and a part of Indian Ocean - Continental plate
5. Eurasian Plate covering Asia and Europe - Continental plate
6. North American Plate covering North America and north-east Siberia - Continental plate

7. South American Plate covering South America - Continental plate
8. Pacific Plate covering the Pacific Ocean - Oceanic plate is the largest one.
- Minor plates include the Arabian Plate, the Caribbean Plate, the Juan de Fuca Plate, the Cocos Plate, the Nazca Plate, the Philippine Plate and the Scotia Plate.

Q. What is the concept of plate tectonics?
- Plates are in motion relative to each other and continually changing in shape and size, where most of earthquakes occur in the boundaries.

Q. What are the major types of plate boundaries?
1. Divergent plate [constructive margins]: the direction of motion is often perpendicular to the strike of the boundary (Mid-Atlantic Ridge).
2. Convergent plate [destructive margins]: the direction of motion of the underthrusting plate need not to be at right angles to the trench (Nazca, South American, The Marianas Trench, and The Himalayas).
3. Transform fault [constructive margins]: the relative motion is generally parallel to the fault (The San Andreas Fault)

Q. How can earthquakes be predicted? And where it occurs?
- By time, location, and magnitude. Earthquakes occur along existing faults.

Q. What are: focus and epicenter?
- Focus is the actual point or rupture within the earth [under surface]. Epicenter is the point on earth's surface directly above the focus.

Q. What are the ranges of focal depths?
- Focal depths range from 5 to 700 km, they are:
1. Shallow [0-70 km] occurs in all plate boundaries. 90% occur at depth less than 70 km.
2. Intermediate [70-300 km] occurs in convergent plates.
3. Deep [300-700 km] occurs in convergent plate.

Q. Why there are no earthquakes deeper than 700 km?
- Because of the change to spinel oxides that is probably completed by that depth, which explain the termination of subduction zone seismicity at this depth.

Q. What is Wadati-Benioff zone?
- It is the dipping zone of earthquakes.

Q. What are the major features of velocity structure of the earth?
1. Velocity increases with depth because pressure gets higher.
2. Sudden drop of P-wave at the outer core boundary because outer core is liquid.
3. Sudden changes in velocity and density (670 km) at the lower mantle boundary.
4. Low velocity area at about 200 km corresponded with the Asthenosphere.

Q. Why the inner core is solid and the outer core is liquid?
- Because of the increase in pressure that make it easy to melt.

Q. What is ductile deformation? Depends on what?
- Ductile deformation happens where rock bends of flows. Depends on temperature, pressure, and composition. 10-50 km in continental areas, and 20-60 km in oceanic areas.

Q. What is rock strength beneath continent?
- Rock strength beneath continents is the weakest in the lower crust. Another transition is in the upper mantle.

Q. What is rock strength beneath oceanic crust?
- Because the oceanic crust is thin and is composed of mafic materials [which have higher melting points], there is no brittle-ductile transition. The transition is in the upper mantle.

Q. What is the principle of isostacy?
- The weight or rock columns of the same horizontal crust section must be the same above the depth of compensation. There are two ways to reach isostatic balance:
1. A flat “Moho” and different crustal density [Pratt’s model]: most of the rock columns above the depth of compensation consist of the crust only.
2. A varying “Moho” and same crustal density [Airy’s model]: most of the rock columns above the depth of compensation consist of both the crust and mantle.

Q. What are the geological evidences for continental drift?

1. Fold belts
2. Age provinces
3. Igneous provinces
4. Stratigraphic sections
5. Metallogenic provinces

Q. Sea-floor spreading is the mechanism of what?

1. Generates divergent plate boundaries.
2. Create oceanic crust.
3. Separates continents.

Q. What is hot spot?

- Hot spots are surface manifestation of plumes of hot material ascending from the deep mantle.

Q. What are super plumes? Give examples?

- Super plumes responsible for widespread volcanic activity during the creation of numerous chains of sea mountain where heat transfer to the surface and flow very far because of low viscosity. Examples: Africa and pacific, where both are seen as low-velocity (hot) areas in the lower mantle.

Q. What does ocean ridge represents?

1. Site where new oceanic lithosphere is created.
2. Longest, linear uplifted features on the earth's surface.
3. Characterized by a belt of shallow earthquakes.

Q. What are the separation rates for oceanic ridges?

1. Fast "because of subduction zone": > 90 mm/a (East Pacific Ridge).
2. Intermediate: 50-90 mm/a (Northern East Pacific Rise)
3. Slow "because of no subduction zone": 10-50 mm/a (Atlantic and Mid-Atlantic Ridge)

Q. What are the origins of anomalous beneath the ridges?
1. Thermal expansion of upper mantle beneath the ridge crests.
2. The presence of molten material within the anomalous mantle.
3. A temperature dependent phase change.

Q. What is the source of basalt?
- Peridotite produces basalt.

Q. What is a subduction zone? Give examples?
- Subduction zone is convergent plate boundary where cold dense oceanic lithospheric plate descends into the earth's mantle. Region with earthquakes below 70 km represent subduction zones. Examples: South America, Aleutian, Japan, and Indonesia.

Q. How island arc system formed?
- It formed when oceanic lithosphere is subducted beneath oceanic lithosphere.

Q. What is the definition of continental rift? Give examples?
- Elongate depression where the entire lithosphere is deformed under the influence of extensional forces. Examples: East African Rift and Baikal rift.

Q. What causes: active and passive rifting?
- Active rifting: results from local tension associated with underlying upper mantle plume. Characterized by initial regional doming of the crust, extensive volcanism and late stage graben formation.
- Passive rifting: response to regional far field stress. Characterized by initial graben formation, local uplift of graben shoulders, little or no volcanism.

Q. What is convection processes?
1. Convection takes place in a fluid when it is heated from below.
2. Density inhomogeneity is created.
3. The heated material attains a negative density contrast with respect to surroundings.

Q. Where does convection occur?

- There is no general agreement if the convection occurs as a mantle wide convection or in paired cells above the mantle transition zone.

Q. What are the earth's major spheres?

1. Hydrosphere "water".
2. Atmosphere "air".
3. Solid earth "rock".
4. Biosphere "all life on the planet".

Q. What is crystallization?

- When magma cools and solidifies and form igneous rock.

Q. What is lithification?

- When sediments compacted by weight of overlying layers or when cemented fills the pores with minerals matter.

Q. What are the differences between continental and oceanic crust?

1. Continental crust: is the layer of granitic, sedimentary, and metamorphic rocks.

Composition: upper layer consist of granitic (50 % silica), and the lower crust composed of basalt and diorite (30 % silica).
Thickness: average 35-40 km but may exceed 70 km.
Density: low density about 2.7 g/cm^3.
Age: old ate age of 4 billion years old

2. Oceanic crust: is a primarily mafic rock.

Composition: 1st layer is unconsolidated sediment, 2nd layer pillow basalt and basalt dike, and 3rd layer is gabbro.
Thickness: less than 10 km.
Density: high density about 3.3 g/cm^3.
Age: young at age of 180 million years old

Q. What are earth's layers based on the physical "modern" properties?

1. Lithosphere "crust": average of about 100 km but may be more than 250 km thick below older portions of the continents. In the ocean, is only few km thick.
2. Asthenosphere "upper mantle": is up to 660 km which is soft and weak layer. The top layer has a high temperature and pressures that result in a small amount of melting. Rocks can easily deform.
3. Mesosphere: depth between 660 and 2900 km where rocks are very hot and flow.
4. Outer core: is liquid layer 2270 km thick. It is the convection flow of metallic iron that generate earth's magnetic field.
5. Inner core: radius of 3486 km and stronger than the outer core and behave like a solid.

Q. What are earth's layers based on the chemical "classic" properties?

1. Crust: usually thin, rocky outer skin, and is gradually divided into oceanic and continental crust.
2. Mantle: over 82% of earth's volume, contained the mantles to depth of 2900 km. peridotite is the dominant rock type.
3. Core: the composition is iron-nickel; the average density is 11 g/cm^3.

Q. What is the average spreading rate of seafloor spreading?

1. Low is 2.5 cm/year as in North Atlantic.
2. Fast is 20 cm/year as in East Pacific Rise.

Q. What is pore pressure?

- It is the open space between particles.

Q. What is the geologic time scale? And its era?

- A geologic time scale was developed to show the sequence of events based on relative dating principles.
- Eons represent the greatest expanses of time. The eon that began about 540 million years ago is the Phanerozoic, "visible life". The Phanerozoic eon is divided into eras. The three eras within the Phanerozoic are the Paleozoic "ancient life", the Mesozoic "middle life", and the Cenozoic "recent life". Each era is subdivided into time units known as periods. The Paleozoic has seven, the Mesozoic three, and the Cenozoic two. Each period is divided into smaller units called epochs. The Cambrian is divided into three eons, the Hadean "world of departed spirit", the Archean "ancient", and the Proterozoic "before life". They are also referring as the Precambrian.

Q. What is deformation?

- Deformation refers to all changes in the original form and/or size of a rock body. It also produces changes in the location and orientation of rock

Q. What are the types of stress?

1. Differential stress: when stress is applied unequally in different directions
2. Tensional stress: when stress tends to elongate or pull apart a rock unit.
3. Strain: where differential stress causes rocks to move relative to each other in such a way that their original size and shape are preserved.

Q. What do the geophysical techniques provide?

- It provides information on the internal structure and tectonic development of the earth.

Q. What do seismic reflection data provide?

- It provides details within sedimentary basin, lower crust, and “Moho” the crust/mantle transition.

Q. What do seismic refraction data provide?

- It provides constraints on crustal thickness changes and seismic velocities within the crust. They are also useful for mapping depth to bedrock, crustal thickness, and uppermost mantle velocity. It is a tool for oil and gas exploration in sedimentary basins.

Q. What do seismic velocities data provide?

- It provides constraints on the composition and physical state of portions of the earth. They also show details of layering within sedimentary basins and gross structure of the deeper crust

Q. Why do earthquakes occur?

- Earthquakes occur because materials are stresses to their breaking point.

Q. Where do earthquakes occur?

- Most earthquakes occur along or near plate boundaries, within the brittle regime near the top of the rigid plates.

Q. What are the types of seismic waves?

1. Body waves: are the waves that travel through the body of the earth.

1.1 P-waves: are compressional waves- like sound waves- that travel quickly through rock. Particles move at the same direction as the wave's propagation direction. P-waves are used for shallow exploration and oil exploration.

2.1 S-waves: secondary or shearing, no volume change. Particles move perpendicular to the wave's propagation direction and travel at about half the speed of P-waves. S-waves are shear waves that push material at right angles to their path of travel.

2. Surface waves: are the waves that travel along the surface of the earth.

2.1 Rayleigh waves: the ground surface moves in a rolling, elliptical motion that dies down with depth beneath the surface. No volume change because of shear stress. In Rayleigh waves, amplitude decrease dramatically with depth.

2.2 Love waves: the ground shakes sideways, with no vertical motion. The vibrating direction is perpendicular to the wave propagation direction. In general, Rayleigh & Love waves are noise waves, so seismologists do not want them.

Q. What are the average velocities of Vp & Vs in the crust and the upper mantle?

Crust: Vp < 7.6 km/s and Vs < 4.4 km/s

Upper mantle: Vp > 7.8 km/s and Vs > 4.5 km/s

Q. At what depth is the Moho? And where is the deepest depth?

- Moho is the layer that separates the crust from the upper mantle, it is considered as a chemical boundary. It ranges from 5-40 km depth and it lies within the lithosphere. The deepest depth is beneath Tibetan Plateau, around 75 km below the surface.

Q. What is the core-mantle boundary?

- It is a low velocity at the outer core (P shadow zone between 103^{o} and 143^{o}), where P-wave delayed with the absent of S-wave.

Q. What are the forces that drive plate motion?

1. Slab pull
2. Ridge push
3. Slab suction

Q. What is acoustic impedance?

- It is the product of seismic velocity and density.

Q. What are the differences between stress and strain?

1. Stress: Is the force acting in unit area on a surface (Stress=F/A). Stress unit is Pascal, where 1 Pascal= 1 N/m^2.
Types of stress: 1. Normal stress “surface”. 2. Shear stress “parallel”
2. Strain: Is the resulting deformation of stress.
- Types of strain: 1. Elastic strain: is proportional to the apply stress (Seismology focus on this type). 2. Plastic strain: where rupture occur. This is more complex.

Q. What is Poisson’s ratio? What is the average of it in both contintal and oceanic crust?

- Measure the change of the diameter that is proportional to the change of length. When a sample of material is stretched in one direction it tends to get thinner in the other two directions. It is in the range of 0-0.5. The average continental crustal Poisson’s ratio is around 0.265 and that of the oceanic crust is 0.30. Upper curst (0.253), mid crust (0.273 to 0.283), and lower crust (0.265).
- Quartzite has a low ratio, granite has a high ratio, and mafic has a higher ratio.

Q. What do affect Poisson’s ratio?

1. Temperature and pressure: the ration increase with increased pressure.
2. Minerals and rock comparison: there is a change in the ratio due to the presence of traces of feldspars.
3. Silica content: it increases Vs and thus decreases the ratio.
4. Igneous rocks: the ratio in this rock type is found to be highly variable. The ratio increase as the composition changes from granitic to dioritic.