SEISMOLOGY

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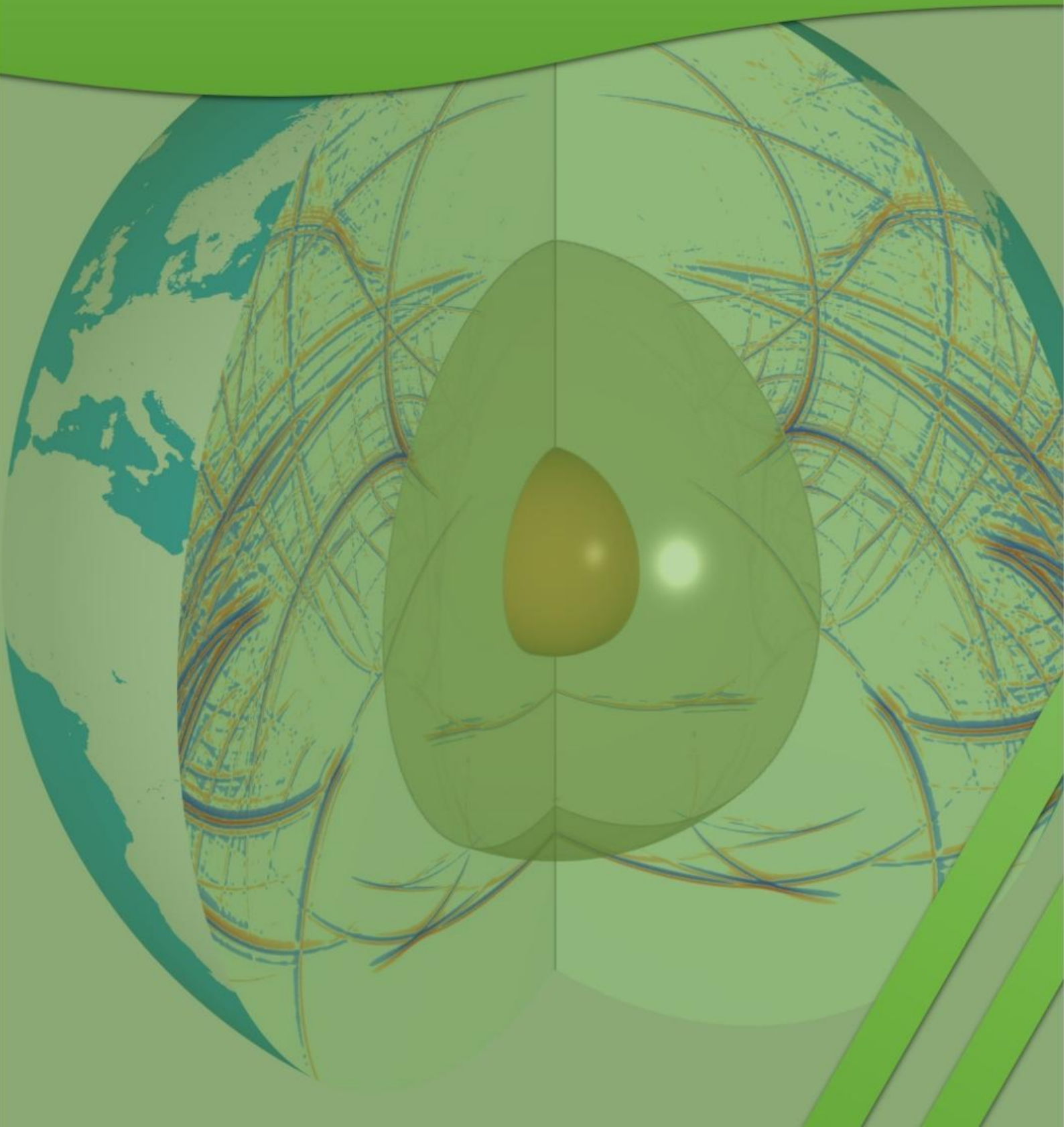


EARTHQUAKES

- **Seismology**: the science dealing with earthquakes
- **Seismograph (or accelerograph)**: instrument for recording EQ's (depends on ground acceleration)
- **Seismogram**: earthquake record (in case of ground acceleration recording the accelerogram)
- **Tsunami**: waves on sea induced by earthquake the focus of which is under the sea bottom
- **Mikroseisms**: permanent Earth's surface vibration
- **Earthquakes**: unpredictable phenomena, sudden release of energy in the earth interior which cause ground vibration on the surface (if energy exceeds physical limits: stress & phase transition limits)
  - The Earthquakes may have ***natural (passive)*** or ***artificial (active)*** origin as a consequences of technological processe, natural phenomena, meteorite, aircraft, bomb…etc
  - **Observed as** surface vibrations
  - **enable the Earth's interior research** (Earth's crust, mantle, external core, internal core)
  - The nature of earthquakes can be explained by means of the plate tectonic theory
- **Physical models of the earthquake:** rheology
- **Rheology:** Physical models of the earthquakes, study the deformation & behavior of matters
- A general study of earthquakes involves many scientific disciplines that deal with the problem:

Seismology ↔ Engineering ↔ Economy ↔ Psychology

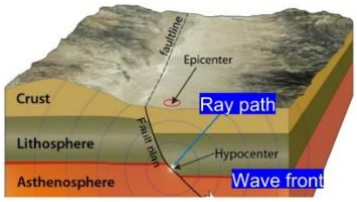
  - The damage to building have several economic, social, psychological, & political effects
  - **EQs Causes** harm, loss on human assets (live, health), property, infrastructure, environment
  - Earthquake is the most devastating natural hazards if considered in relation with structures
  - The problem arises from the structure under seismic excitation & not the earthquake itself
  - The EQ has begun to become a problem for humans since they started to build structures
- **Seismic engineering:** the discipline the aim of which is to construct infrastructures & buildings resistant to earthquake & similar phenomena impacts & by this way to protect human lives, health, & human property
  - Branch of engineering devoted to mitigating earthquake hazards, It covers the investigation & solutions of problems of damaging structures
- **Earthquake parameters**: focal depth, size, & geographic coordination of epicenter
- **Size of Earthquakes are measured by:**
  - Intensity (I), Energy (E_T), & stress drop ($\Delta\sigma$)
  - Seismic Energy (E), & Moments (Mo)
  - Magnitude (M) : by Reichert scale
  - Acceleration (a), velocity (v), & displacement (d)
- The relative movements of rocks & plates cause sudden energy released in the form acoustic waves & this waves than transformed into the earth's surface which cause an earthquakes
- In general, the Earthquakes can do not kill people, but unsafe structures do!

NATURE OF EARTHQUAKE

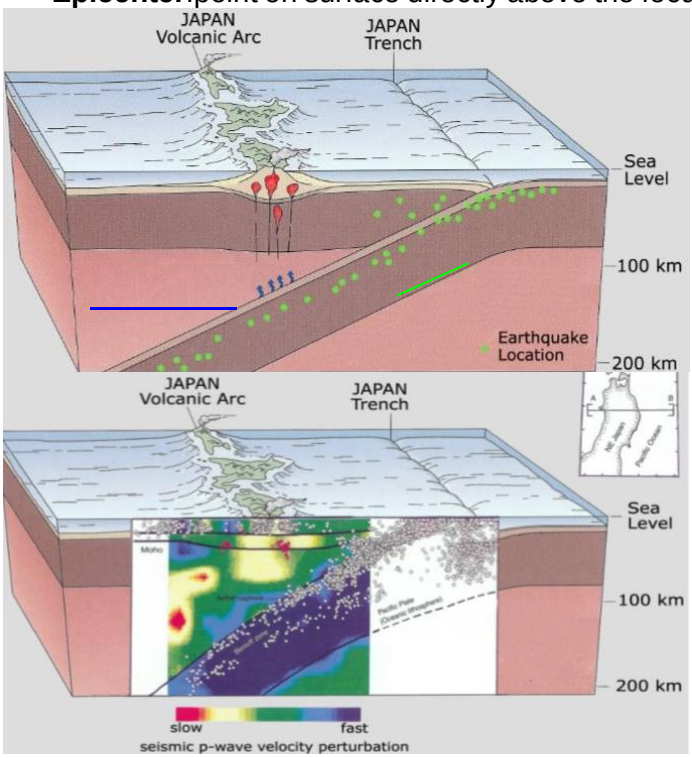
- **Earthquake foci**: mostly on lithosphere boundaries
  - **Daily**: 8000 earthquakes ≤2 magnitude

Annually Earthquakes	Magnitude	Frequency
Medium	≥4	7000-9000
Strong	6-7	18-20
Very strong	≥1	≥8

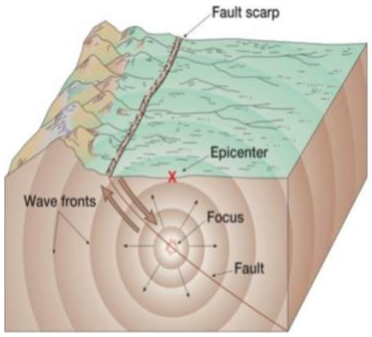
- **Focus (hypocenter):** Location within the Earth where the earthquake occurred or location on a fault where slip first occur



- **Epicenter**:point on surface directly above the focus



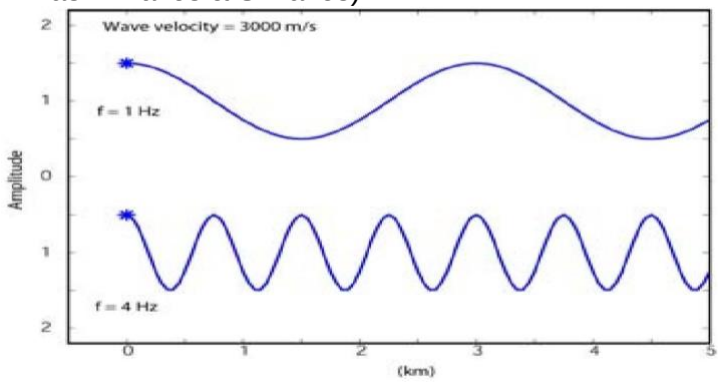
- **Focal depth:** distance between the focus & the epicenter
- **Epicenter distance**: distance between a site & epicenter
- **EQ locations**: starts at the focus which is the fault zone along which the EQ slips



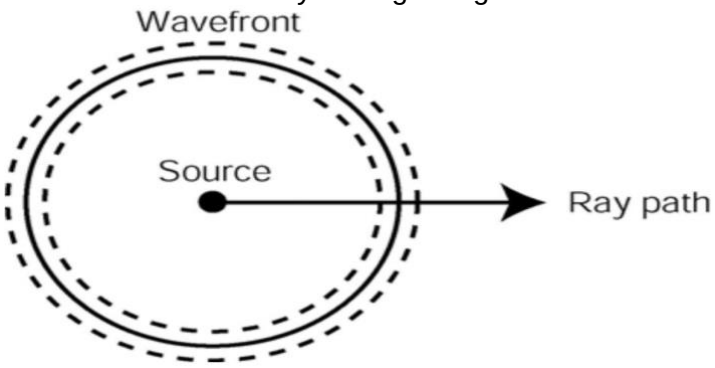
- **EQ is completely described by 2 parameters (the most common are magnitude, & intensity)**
- **EQs are often located by epicenter** (point on the surface of the earth right above the focus) by tangential method
  - **The separation in time of 1st arrival of the P- & S-waves** correlates directly with the distance of EQ from the station & the distance can be graphed on *travel-time curve*
  - Several stations necessary to pin-point the location of EQ by *drawing a circle* with *radius = distance between the epicenter & the station*
  - The point of intersection of the 3 circles is the epicenter

SEISMIC WAVES

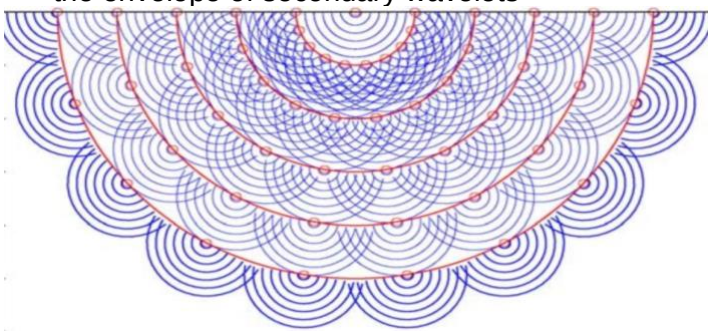
- **A wave**: (displacement or ripples) is a periodic disturbance, transmits energy through a medium, without the permanent displacement of the medium
- **Frequency (f):** The number of cycles a given point moves through in 1 second. measured in Hertz (Hz)
- **The period of the signal (T):** number of rotations per second (for very low frequency), T = 1/f
- **Angular frequency (ω)**: is the number of radians per second & given by ω=2πf
- **Wavelength (λ)**: Distance in m between 2 points of the wave having the same phase (crests, troughs)
- If the waves moves at a velocity (v), then v = f λ
- **Dispersive wave**: If v varies with f (e.g. Surface)
- **Non-dispersive wave**: If v is independent of f (such as P-waves & S-waves)



- **Rays:** is the direction in which the wave travels
- **Wavefronts:** are points on the wave with the same phase (e.g. a line along the crest of a wave)
  - ➢ wavefronts & rays: at right angles to each other

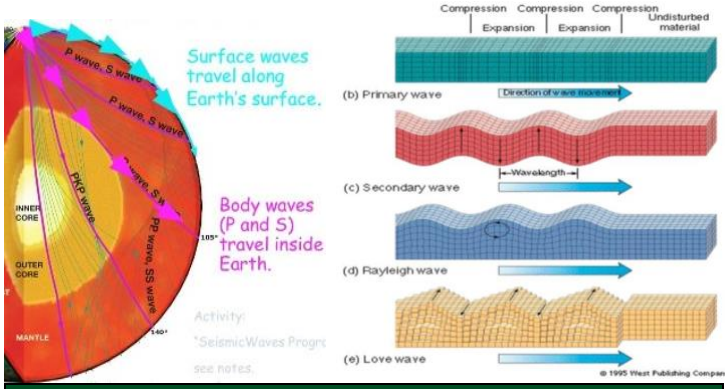


- **Huyghens Principle**: visualize wave propagation over time, all points on a wavefront are considered secondary sources of wavelets that propagate outwards & at a time later, the overall wavefront is the envelope of secondary wavelets

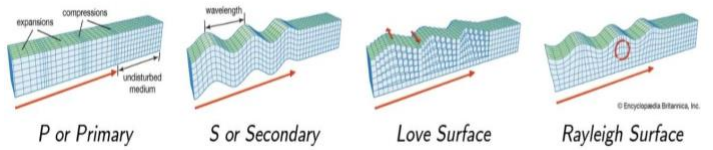


- **Earthquake's waves**: body & surface waves
- تم تقسيم الموجات الزلزالية بناء على اي وسط تمشي به (السطح او داخل الصخور) وعلى سرعتها وايضا على الية وشكل الحركة

Body waves	Travel from focus in all directions (radiate outward in all directions, go inside the bodies) • Faster, Velocity of wave depend on λ • Travel through the bulk medium • The velocity can be calculated from the properties of the material
Surface waves	Travel around the earth & confined to interface (travel along surface of the Earth & decrease in amplitude with depth, go on the surface) • Slower, & travels at one velocity • Cause most damage because produce more ground movement & travel more slowly, so they take longer to pass



Types of Body waves	
P-wave	• ***Primary***, ***Longitudinal*** or ***Compressional*** • **Characterized by** vibrations parallel to the propagation direction of wave so it fastest (Particle motion in the same direction as the wave propagation) • Travels at 5-7km/s near the surface • Can pass through the liquid & solid • Are a horizontal waves
S-wave	• ***Secondary, Shear Waves, or transverse*** • **Characterized by** a series of sidewise or shearing movements so it slower than P • Particle motion is at right angles to the wave propagation • Cannot pass through a liquid • Are a vertical waves
Types of Surface waves	
Rayleigh Waves	• Occur on the surface of any object such as ripples on a lake. • Large EQ can generate surface waves that travel around the globe. They can be large in amplitude & cause a lot of damage • ground roll is a Rayleigh wave that travels across the geophone array • The velocity of does not vary with frequency when travelling in a uniform medium and it is slower than an S-wave • In a layered Earth the velocity of a Rayleigh wave varies with frequency (it is dispersive) & can be used to infer velocity
Love waves	• have a horizontal particle motion, & only exist if the Earth is layered and • always dispersive



- تقسم الموجات الزلزالية الى passive وهي الزلازل التي تحدث بشكل طبيعي و active وهي زلازل من صنع الانسان, وترصد موجات ال earthquake في ال passive اما ال geophone في ال active التي تحتوى غالبا strong motion sensor stations

CLASSIFICATION OF EQ

- *Aristotle* classified earthquake into 6 categories based on observed surface movement, & Chinese scientist *Chen* constructed instrument for earthquake registration

Earthquakes	Depth [Km]	No EQs below 700 km. At greater depths rocks very hot & under high P deform by flowing rather than breaking & faulting
Shallow	0 – 70	
Intermediate	70 – 300	
Depth	300 – 700	

- Shallow-focus EQs occur more than deeper ones (75% of the total EQ), the shallower EQs the more damage it can produce at the surface; intermediate & deep-focus earthquakes are rarely destructive
- **Magnitude:** measure of released energy during EQ & doesn't related to epicentral distance or damage
  - ***Richter Scale***: Max amplitudes of P & S waves (height of the waves) 100 km from an epicenter
  - 1 magnitude → 10 times ground motion (displacement) → 32 times more energy

Descriptor	Magnitude	Avg.Annually (frequency)
Great	8 - >8	1 (observations 1900)
Major	7 – 7.9	17 (observations 1990)
Strong	6 – 6.9	143 (observations 1990)
Moderate	5 – 5.9	1319 (observations 1990)
Light	4 – 4.9	13,000 (estimated)
Minor	3 – 3.9	130,000 (estimated)
Very Minor	2 – 2.9	1,300,000 (estimated)
Δmagnitude	**ΔEnergy**	**Displacement (ground)**
1.0	32 times	1.0 times
0.5	5.5 times	3.2 times
0.3	3.0 times	2.0 times
0.1	1.4 times	1.3 times

$$M_L = log^{\frac{A}{A'}}$$

M: local magnitude, A: amplitude (μm), A': amplitude of 0 M

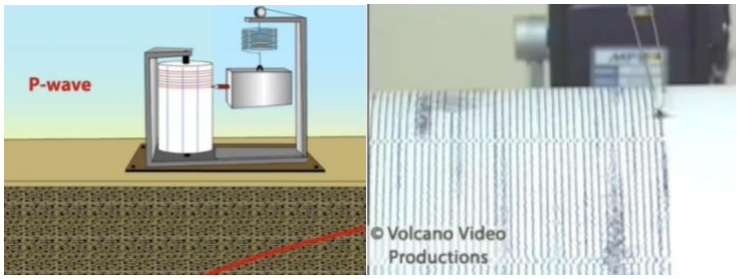
- **Intensity:** actual observations of earthquake effects (performance of builduing structures, natural phenomena, & human perceptions)
  - It depends on the epicentral distance, local soil conditions, geology, & topography (the largest intensity is observed near the epicentre)
  - The intensity scale consists of series of certain key response such as awaking, movement of failure, damages or total destruction
  - ***Modified Mercalli Intensity*** (MMI) (12 levels)
  - It does not have a mathematical basis

Level	Damage & Affect
1, i, Instrumental	Detected only by seismographs
2, ii, Feeble	Noticed only by sensitive people
3, iii, Slight	Resembling vibrations caused by heavy traffic
4, iv, Moderate	by people walking, & rocking of standing things
5, v, Rather Strong	Sleepers awakened & bells ring
6, vi, Strong	Trees sway, by overturning & falling things
7, vii, Very Strong	General alarm, cracking of walls
8, viii, Destructive	Chimneys fall & some damage to buildings
9, ix, Ruinous	Ground crack, houses collapse & pipes reak
10, x, Disastrous	Ground badly cracked & many buildings are destroyed with some landslides
11, xi, Very Disastrous	Few building remain standing; bridge & railway destroyed; water, gas, & electricity out of action
12, xii, Catastrophic	Total destruction; shaking, & ground's distortion

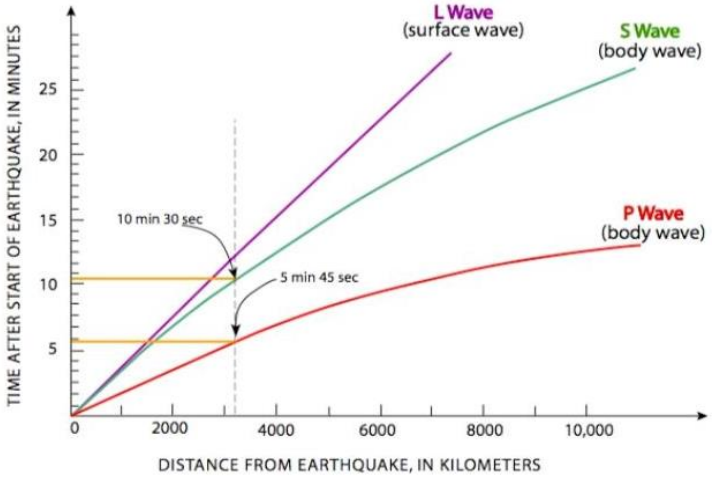
Magnitude	Intensity
Based on motion with instruments (seismographs)	Based on observations of EQ effects on building & human perceptions
unique indicator of a size of EQ. Each EQ characterized with a single value which indicates its magnitude	It's not a unique indicator of a size of EQ. Each EQ is characterized with various intensities, depending on the location from the epicentre
modern indicator. not measures of historical EQ	evaluated for historical EQ basing on the analysis of written source

DETECTION-PRODUCTION

- When an EQ occurs, the seismic waves travel through the Earth to the seismic station where the information is transmitted to distant computers
- **vertical seismometer** record P & S waves arrivals

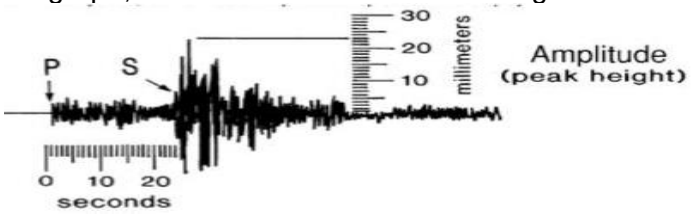


- Seismologists determine travel times for seismic waves by analyzing wave from thousands of EQ's



Use S-arrival time minus P-arrival time to determine the distance from the travel-time curves

- **To locate the earthquake**: Determine distance of EQ from 3seismic stations by calculating S-P arrival times (distance in time), Plot them on travel-time graph, then Intersection of the circles gives location



- Most of the energy is released by around 20 magnitude 7 or larger earthquakes every year

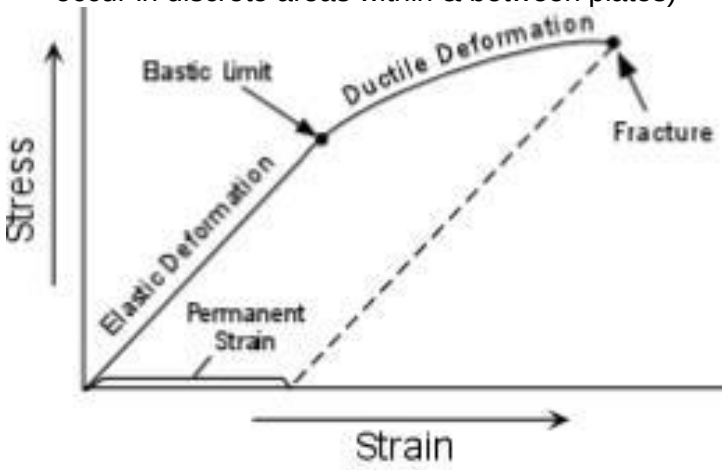
ممكن ان تحدث زلازل اكثر من 8 ولكن دمارها يشمل المراصد لذا لا ترصد،
والزلازل الاقوى الممكن ان تحدث في الاردن هي Moderate

- **Earthquake prediction eludes us**: interplay of forces, faults, & friction is unpredictable, if rocks on fault move, elastic energy is being stored & released in earthquake
- If we determine the history of earthquakes on a particular fault, we can forecast the probabilities of earthquakes occurring on segments of fault. Earthquake forecasting is valuable because this tells us where we must construct earthquake-resistant buildings, highways, & bridges
- **Travel time curve-f (A, h):** dependence of time spreading the real wave on epicentral (hypocentral) distance & depends on wave type

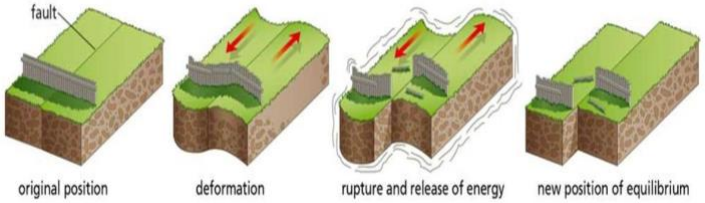
$$t(r) = T - H,\ travel\ t = t_{site} - t_{focus}$$

EQ'S MECHANISMS

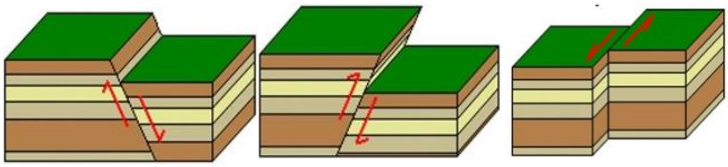
- Earthquakes occurs due to brittle diffraction of a lithospheric plates (e.g. Subduction-zone EQ's occur in discrete areas within & between plates)



- The EQ mechanism related to force, fault, friction
- **Fault:** break in the rock where there is movements (Cracks along which rocks slip, may break through the ground surface, or remain deed within earth)
- **Elastic rebound:** The earth is elastic body which can be strained during plate tectonic processes
  - Fault zone at the boundary of large lithospheric plates lock despite the motion of the plates
  - large strains accumulate in rocks next to fault zone, & stresses become so large at the locked fault zones rupture & slip & This rapid slippage releases strain energy which was accumulated over a long period of time in a process called ***elastic rebound***
  - slips seismic waves are released at fault zone
  - EQ are vibrations that caused by the fracture of the crust or by sudden movement along a fault
  - The fracture or slippage emits large amounts of energy in the form of seismic waves that travel through the earth's interior & across surface



The most common mechanisms of earthquake sources	
Normal faults	The block above (hanging wall) moves down relative to the block below (foot wall) • ***Tensional force*** & results in ***Extension***
Reverse faults	The block above the fault (foot wall) moves up relative to the block below (hanging wall) • ***Compression force,*** result in ***Shortening***
Strike-Slip	The movement of blocks is horizontal • Caused By ***shearing forces***
Oblique-Slip	Suggests both dip-slip & strike-slip faulting • By ***combination of shearing & tension or compressional forces***



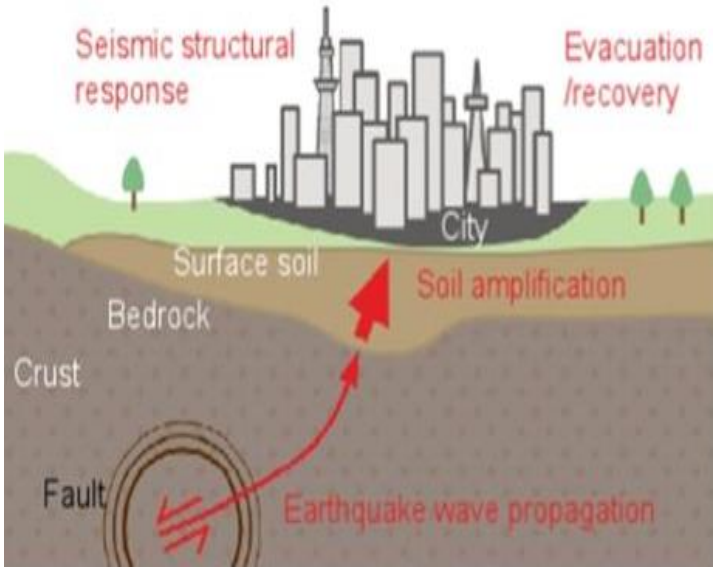
DISTRIBUTION OF EQ

تتركز البؤر الزلزالية عند حدود الصفائح لكن يمكن ان توجد داخل الصفيحة عند مناطق ال fault او المناطق النشطة جيولوجيا
كلما كانت البؤرة اقرب للسطح كلما كان الزلزال اقوى
ال subduction هو نطاق غطس ينتج عن التقاء صفيحتين احدهما قارية والاخرى محيطية وتغطس المحيطية (الاكثر كثافة) او محيطية مع محيطية وتغطس الاقدم (وهي الاكثر كثافة)

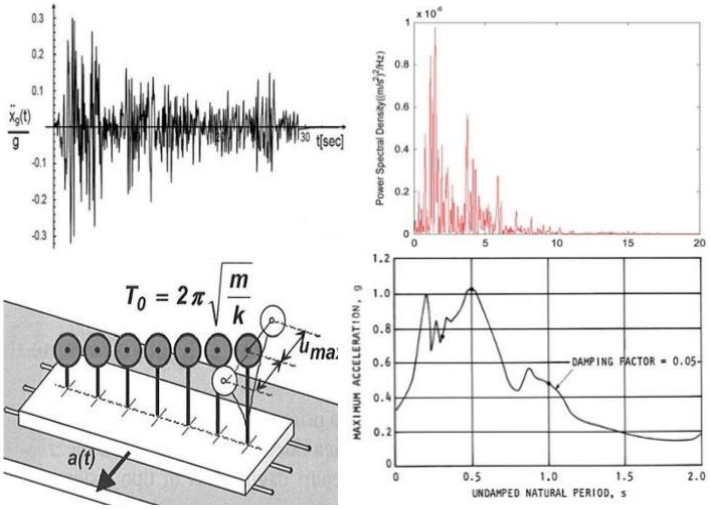
- **Recorded seismic events:** natural EQs, induced EQ's (man-made), & artificial explosions
- **Natural EQs:** tectonic origin (90%), volcanic origin (7%), & collapse of underground spaces (3%)
  - The most harms & losses on human assets are caused by tectonic earthquakes
  - Concentrated at plate boundaries, & Mostly occur along edge of oceanic-continental plates
- **Induced EQs**: artificially triggered seismicity
  - **Cause**: the perturbation of underground mechanical equilibrium, due to industrial activity (mining, dams, geothermal, hydrocarbon reservoirs) induce deformation of involved sites
  - located in different tectonic settings
- **Induced earthquakes types:**
  1. reservoir induced seismicity(eg.Lake Kremasta)
  2. rockbursts, mining, rockfalls, shaking, bumps, outbursts (methane release)
  3. seismicity triggered by injection of fluids into rocks, special technology of mining
  4. seismicity triggered by withdrawn of fluids from surface formation, special technology of mining
  5. earthquakes stimulated by seismic vibration signals, by special technology of mining
  6. earthquakes that stimulated by artificial explosions (mining regions, test sites)
- The stress increases where plates bump into each other, pulling awayor past from each other
- **reason of high seismic hazard in Mediterranean** is collision of African-EuroAsian plates
- **Earthquake prediction**: Because lithospheric plates slip past each other at a well known rate, it is possible to determine the frequency with which large faults slip must slip in order to keep up the general motion of lithospheric motion
  - Because most large faults are locked, infrequent earthquake slip will take up slip accumulated over a long period of time
  - Based on size of EQs, slip can be released as often as once every dozen years to 300-400yr
  - With such information geophysicists can make predictions about when the next EQs will occur
- **Worldwide distribution of EQs:** Earthquakes can occur most anywhere in the crust of the earth
  - most of the very large EQs occur in several belts (boundary of the large lithospheric plates)
  - On a map of world wide EQs distribution, the most concentrated belt is circum Pacific belt, & Another major concentration of earthquakes is in Mediterranean Himalayan belt
  - Shallow focus EQ's occur along summit of MOR
  - Deep focus EQs found below ocean trenches in steeply dipping zones called Benioff zones

EQs CHARACTERISATION

- Most EQ rather short in duration, often lasting only a few seconds & seldom more than minute or more
- The intensity of EQ is measured in terms of energy released at the ground fault, the critical effects on the given structures is determined by ground movements at the location of the structure
- The effect of the movements is affected mostly by the distance of the structure from the epicentre, & by geological conditions directly beneath structure
- Acceleration is the most common representation in one horizontal direction plotted as a function of elapsed time (measured by accelerogram "a-gram")

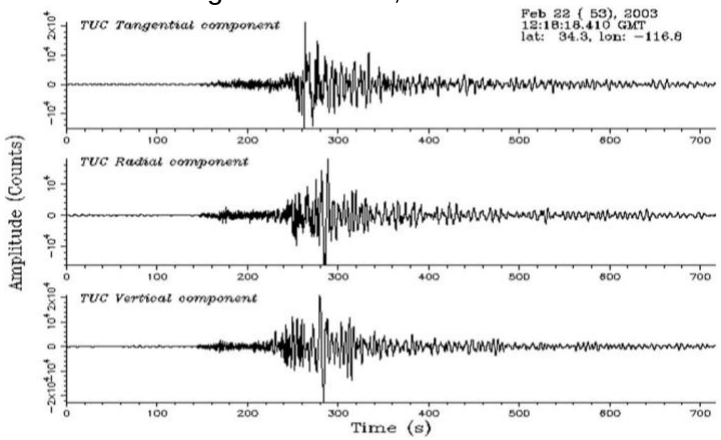


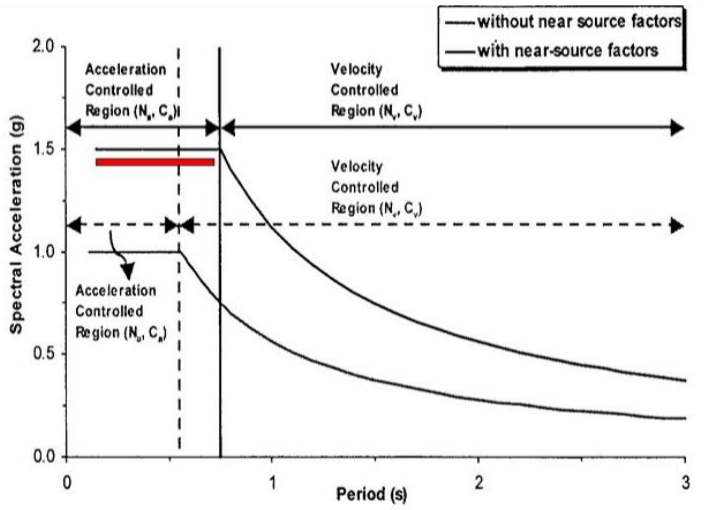
- How can we say if an a-gram is hard for a structure
  - **Peak Ground Acceleration (PGA)**: The peak value in absolute value terms
  - **Strong motion Duration**: Structural damage strongly depends on the number of load cycles
  - **Fourier Spectrum:** representation of a time history into the frequency domain & defined as *Fourier Transform of ground motion time history*
  - **Analysis of frequency content**: is the description of the frequency composition
  - **Acceleration Response Spectrum**: peak of acceleration of a series of oscillators of varying natural frequency, that are forced into motion by the same ground motion. it may be considered the main tool to evaluate seismic load



EQ'S FOCI & WAVES

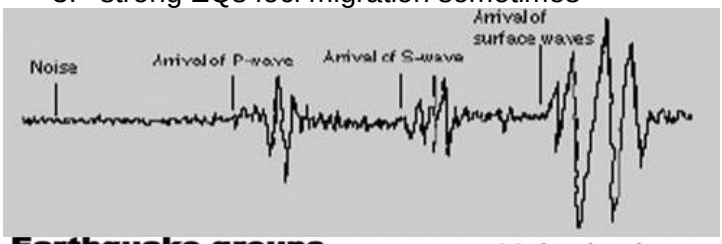
- **Length of time interval P-S inputs depends on** epicentral distance & recording place
  - As increase of epicentral distance seismogram complexity increase as a consequence of recording the reflected, surface & other waves

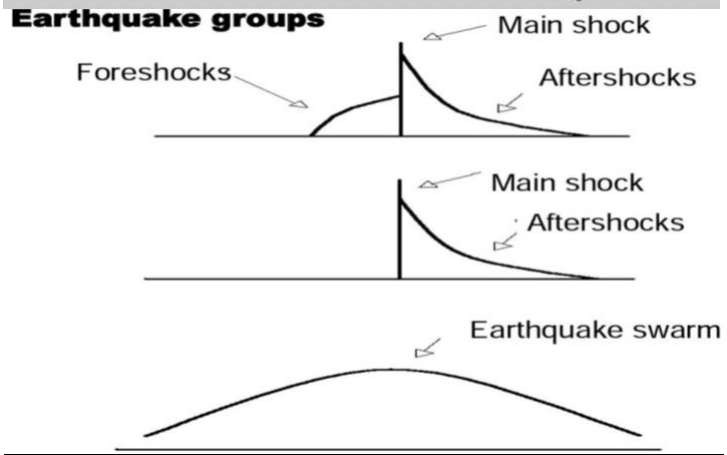




- The earthquake foci concentrate to regions called "**focal provinces-zones or regions**", & The boundary of focal provinces are defined as a boundary that surrounds:
  1. all known EQ foci occurring in the historical time & case when they're evidence on prehistorical foci from the research of paleoseismicity
  2. the region in which the EQ with the same characteristics of seismic regime occur
  3. the region with the same geological, tectonic, & recent movements characteristics
- **Findings from research of earthquakes**
  1. From EQ foci space distribution it follows that EQ foci are mostly connected with faults
  2. In recent period only certain parts of faults are seismoactive in both vertical & horizontal plane
  3. EQs often originate on fault crossing, Mostly one of the fault is preferred in historical time form earthquake occurrence viewpoint
  4. In most cases, after strong EQs connected with fault it follows EQs connected with other fault
  5. Isoseismal form in epicentral zone depends on fault, plane mechanisms, in distance zone on material properties-boundary r = 2.5h
  6. Isoseismal surface size depends on EQs size & focal depth & indirectly on intensity attenuation,

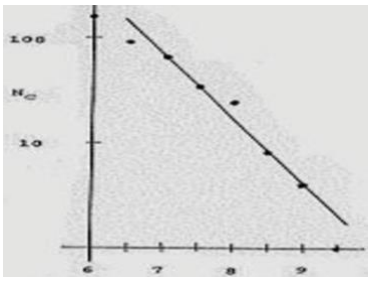
- **Seismic regime of focal zones**: variable in time & space, has a certain prevailing character in each focal zone, & described by the following:
  1. Benioff's graphs & occurrence frequency
  2. EQs group type & space-time foci distribution
  3. strong EQs foci migration sometimes





Viewpoint is determined by value of stress drop:	
High Δg	• low value of the highest aftershock • low number of aftershocks
Low Δg	• high value of the highest aftershock • great number of aftershocks

- **Frequency graph**: distribution of EQs number according to the EQs size (used cumulative frequency in which the sum starts at the biggest EQ)



- **Maximum EQs in focal zone:** predetermined by physical focal zone condition by the following ways
  1. sum of size of Max observed EQs & 1° MSK-64
  2. extrapolation of oscillations of Benioff's graph
  3. curvature of magnitude-frequency graph
  4. correlation of max observed EQ with seismic activity by selected level of earthquake activity
  5. theory of extreme values & Geodynamic factors
  6. correlation of max EQs size with fault length

Max observed intensities map (seismic zoning)

Aftershock & Foreshock Area

SEISMIC RISK

- Seismic risk is defined as the potential economic, social & environmental consequences of hazardous events that may occur in a specified period of time

$$R = H \; x \; V \; x \; E$$

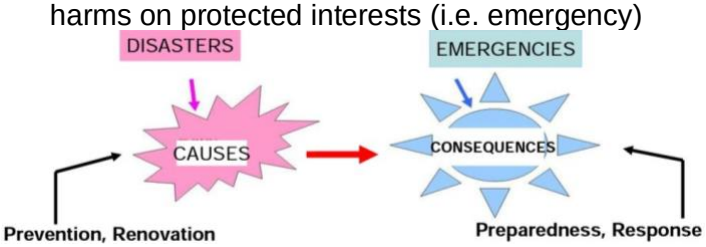
R: risk, H: hazard, V: Vulnerability, E: Exposure

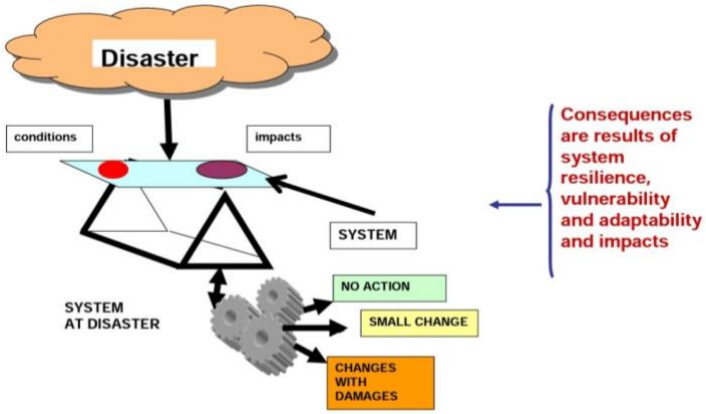
- **Hazard:** Occurrence of EQ of sufficient magnitude capable of causing damage to the structures

Disasters – Hazard | **Risk - Emergency**

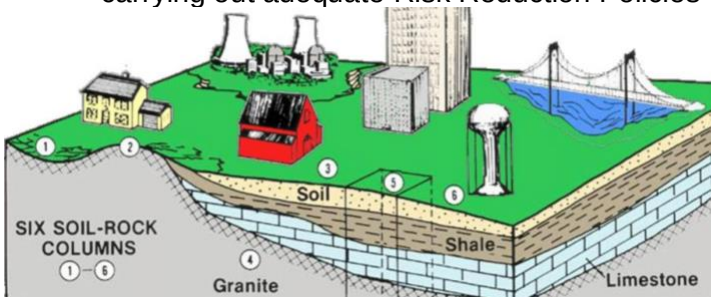
Related to risk sources | Related to protected interests

- **Vulnerability**: Damageability of structures under action of hazard, weaker EQ being more vulnerable
- **Exposure:** Assessment of economical & social consequences. A count of exposed system & value
- Human system is open dynamic system in which there are processes, actions, phenomena, & events the sources of which there are inside & outside of system, & The disasters are their results
- **The disaster** occurrence in a certain site & time causes in dependence on disaster size, physical nature, & amount & vulnerability of protected interests in a given site the looses, damages, & harms on protected interests (i.e. emergency)

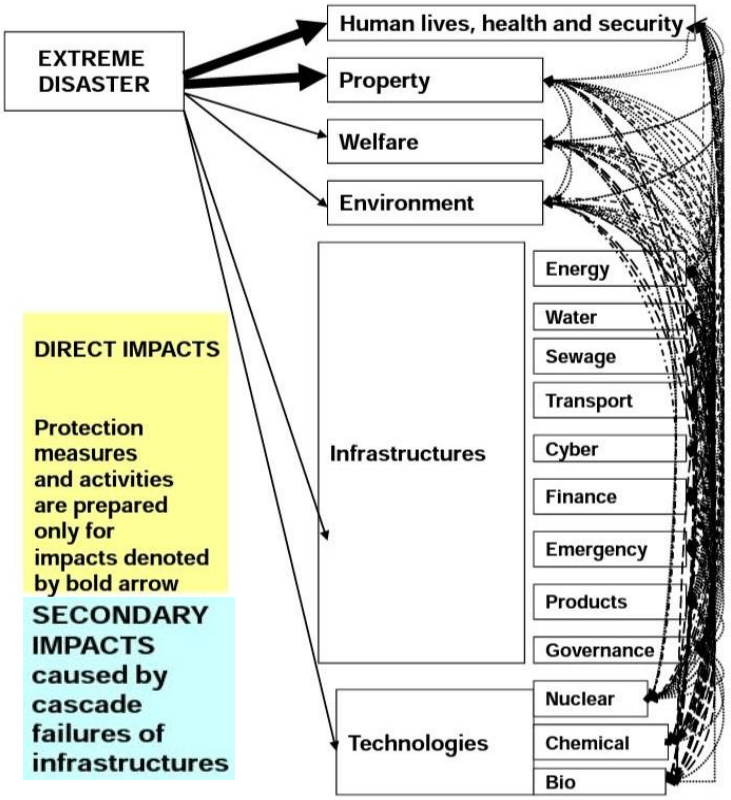


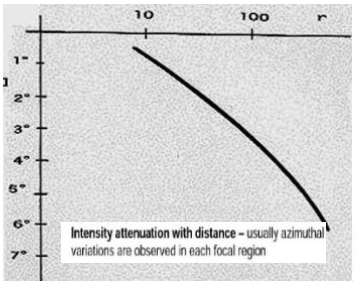


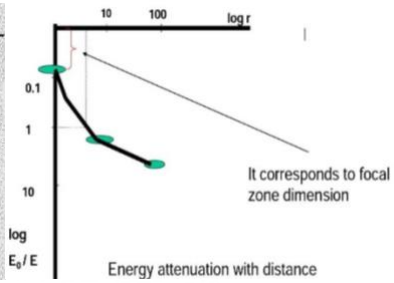
- How can we cut the seismic risk down?
  - ➢ Is not possible to avoid or predict occurrence of EQ, or to eliminate presence of man & structure
  - ➢ It is possible to limit EQ effect (Vulnerability) carrying out adequate Risk Reduction Policies

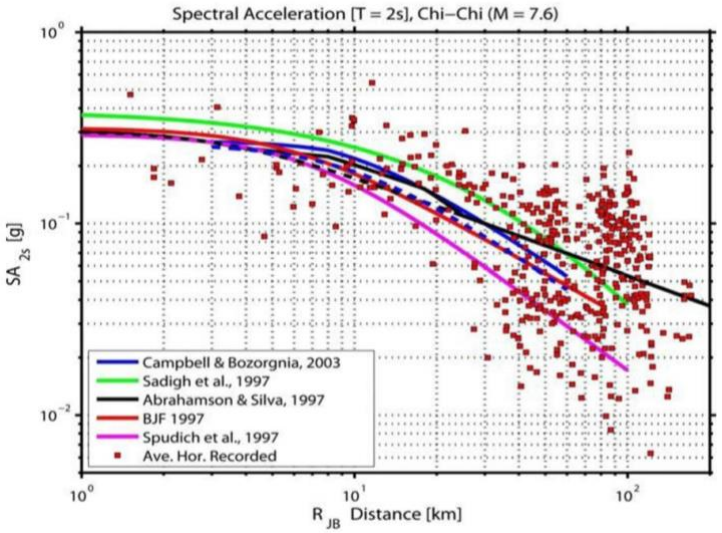


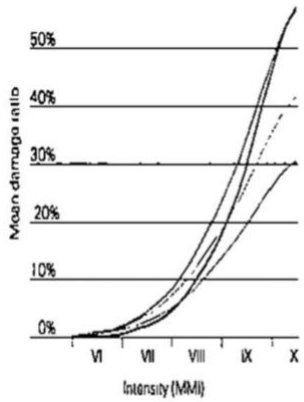
Items for seismic protection

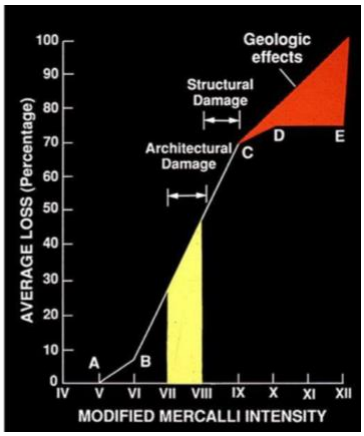










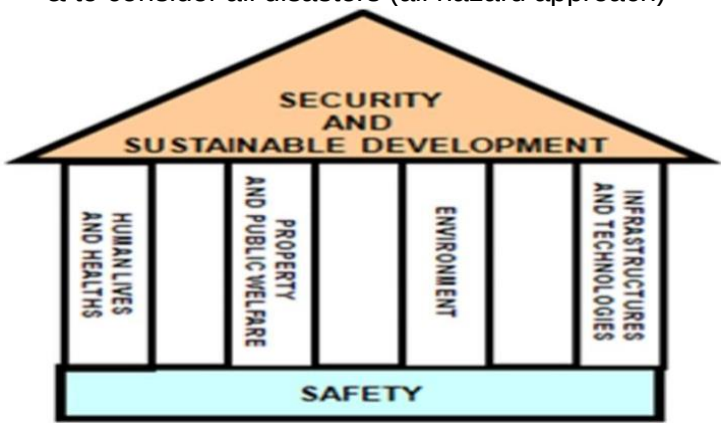


PROTECTION PRINCIPLES

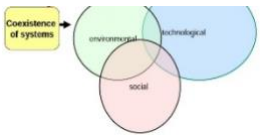
- **Distinguish causes & consequences**

Causes	• Is a Phenomena (Earthquake = Disaster) • Characterized by quantity hazard
Consequences	• Is an events, & emergency situations • Characterized by quantity risk

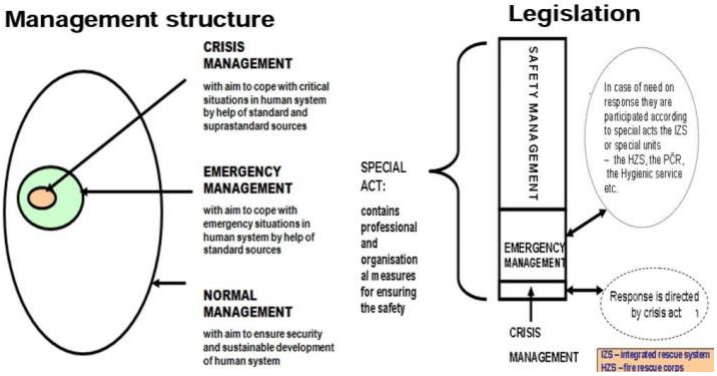
- **human protection:** we must protect public assets & to consider all disasters (all hazard approach)



- **To consider that reality is system of systems (set of system that are mutually interconnected)**



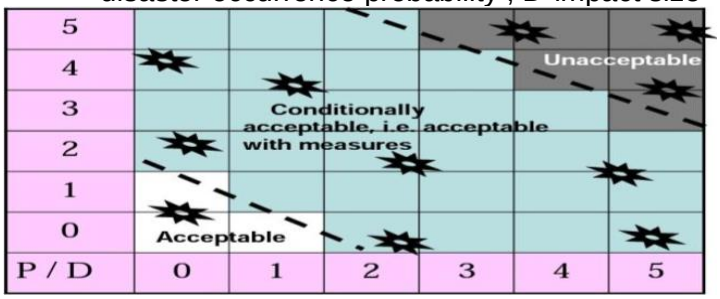
  - ➢ to consider vulnerability, resilience, & adaptation capacity & the reality that we need to ensure coexistence of systems
- To use the 3rd step management & legislation for effective emergency & crisis management



- **Safety Cycle**

Response	• Implementation of measures putting the disaster impacts under control with adequate losses & adequate sources • Alam, life, Reduction of disaster's Impact, Information dissemination, Communication
Rehabilitation	• Temporary rehabilitation, re-established transport system & communication routes
Post disaster	• Damage assessment, follow rehabilitation
Re-construction	• Permanent rehabilitation, infrastructures & building reconstruction, reinforcement
Prevention & Mitigation	• Introduction of protection measure against disasters occurrences & disasters impacts enhancements, active, & passive • Risk assessment, Spatial Planning, Eco-structural measure, awareness, Education
Preparedness & Readiness	• Introduction of measures enhancing our capability to put disasters under the control • Risk forecasting, Organization, Resources & emergency planning,Training,awareness
Renovation	• Implementation of measures for assurance of area reconstruction return to stabilized condition, further society development

- **The effectiveness of measures & activities**
  - ➢ Effectiveness of measure & activity is different
  - ➢ the most effective measures & activity by that we can avert disaster occurrences & mitigate impacts are preventive measures (procurators), the effectiveness of which is the following
  1. **Technical measures** use in the area of land (use planning 60 – 80 %)
  2. **Population education & training** (20 – 30 %)
  3. **Emergency & crisis management** (strategic planning) 25 – 40 %
  4. **Installation of warning & alarm** 9-40%
- **Human technical, & financial sources, forces, & means limited good governance is necessary (tool decision matrix DM)**
  - ➢ **DM for design disaster management:** P-disaster occurrence probability , D-impact size

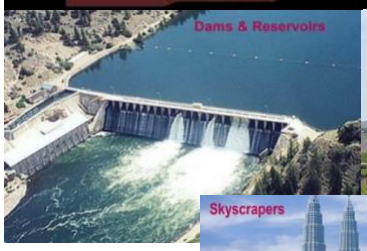


- **To use all state tools for safety support:**
  1. Strategic safety management with aim security & sustainable development
  2. Training & education of population
  3. Specific training technical & senior managers
  4. Technical standards, norms, & regulations (i.e. the regulation of processes that can or could result to an occurrence of disaster)
  5. Research (theoretically, & experimentally)
  6. Inspections
  7. Efficient forces for putting the disasters under control (fire-fighter, police, medical doctors)
  8. Emergency & crisis managements belonging to standard state strategic management
- **Reserves for crisis management**
  1. Emergency management uses standard forces, sources, & means
  2. Crisis management uses standard + beyond standard forces, sources, & means
- **RESEARCH**: Seismic tests, shaking table
- **State safety management system** ensuring the disaster protection in the EQ & its Member States:
  1. Protect the human lives & health, property, environment, & technical infrastructure
  2. Considers relevant disaster with possible occurrence on territory & against relevant disasters it carries out prevention & preparedness with regard to impacts
  3. Forms the professional base, managerial structure, efficient forces means, substances, & sources to ensure protection of human lives & health, property, environment & of the state
  4. Forms professional base, managerial structure, efficient forces, means, substances & sources to ensure renovation after disaster & after crisis

EQs CAUSES & AFFECTS

- EQs is a sudden violent shaking of the ground, causing great destruction, as a result of movements within the earth's crust or Volcanic action

Types Of Earthquake	
Tectonic	occurs when the earth's crust breaks due to geological forces on rocks & adjoining plates that, & cause physical & chemical changes • Around 90% of natural earthquakes • Most common, & most destructive • Occurs at plate boundaries or within continents • Chemical changes occur due to thermal metamorphism near strike slip faults, or by partial melting in the convergent plates
Volcanic	by magma movement (injection, or withdrawal) • Around 7% of natural earthquakes • The movement results in P-changes in rock around where magma experienced stress • Occur in continents due to Hotspot activities
Collapse	are small EQs occuring in regions of underground caverns & mines • The immediate cause of ground shaking is the collapse of the roof of the mine or cavern
Explosion	Results of nuclear & chemical devices. • Occurs when enormous energy is released
Causes Of Earthquake	
Natural Cause	• Slow-moving processes within the Earth • Earth was hot when it formed, & has been cooling ever since (T rises by 30°C/Km depth) • Earth's cooling causes the portions of earth to move, & that movement is what we call EQs
Induced (Human-made)	• Reservoirs (such as dams) • Extraction (such as Groundwater & Oil) • Geothermal Power Plant • Injection Well & Skyscrapers
Effects Of Earthquakes	
Primary	The immediate damage caused by the quake which kill people (collapsing buildings, roads, & bridges) • Can suffer badly from shock and panic
Secondary	Tsunami, Liquefaction, Fire, Disease, & Landslides



LANDSLIDES & TSUNAMIS

- **Some affect of an earthquakes**
  1. **Sounds:** deafening, roaring, creaking, rattling...
  2. **Ground motion:** violent motion, aftershocks…
  3. **Building:**shuddering,shaking,swaying,collapse
  4. **Effect on objects inside buildings:** falling, breakage, shaking….
  5. **Effect on transport:** derailed trains, bent rail tracks, toppled roads…
  6. **Other affects**: Fires, Death, …
  7. **Hazards**: tsunami, landslide, Liquefaction…
- **Landslide:** is a rapid movement of materials down a slope (from huge boulders to soil in sizes)
  - Involve the movement of just a small amount of material or enough to bury towns in their path
  - **Caused by**: have a number of causes, such as EQs, shock of an EQ led to start the slide
- **Tsunami:** ocean waves caused by movement of the ocean floor by an EQ beneath the ocean
  - water moved as it pushed by a giant paddle, producing powerful waves that spread out from the region of the EQ across the ocean
  - hardly detectable in open ocean, having only a low wave height (<1m) but when reach shallow water at a coastline their wave height increases significantly (>10 m) with disastrous effects
  - **Tsunami term:** is a Japanese word meaning *bay* or *harbour wave*, The term *'tidal wave'* inaccurate as they are not related to tides (which are generated on the surface by the gravitational attraction of the Moon & the Sun), the Japanese word is particularly appropriate because Japan has suffered greatly from the destructive effects of tsunami
- **Aftershocks:** series of small EQs on the fault large followed by a large EQ, can continue for months after the main earthquake
  - **Caused by** readjustment in the positions of the rocks following the main EQs, releasing smaller, localised buildups of energy on the fault
- **Foreshocks**: one or more small EQs preceded the main EQ, cannot be identified as foreshocks until after the main EQ has occurred
- EQ are mainly confined to specific areas of the Earth known as **seismic zones**, which coincide mainly with ocean trenches, mid-ocean ridges, & mountain ranges
- **Shallow-focus EQ** occur in all of the Earth's seismic zones
- **Intermediate- & deep-focus** EQs are almost exclusively associated with seismic zones near ocean trenches
- The destructiveness of an EQ depends on the size, the depth (shallow ones are more destructive) & the location
- Earthquake size can be stated in terms of the damage caused the intensity or the amount of ground motion and the energy released by the earthquake (related to the Richter magnitude)

INTENSITY & MAGNITUDE

- **Why are some EQs more destructive than other**
  1. **Location**: e.g. EQs with a focus under ocean at with a large distance from land is non-destructive, unless it generates a tsunami
  2. **Depth**: shallower EQ are more devastating), but, most importantly
  3. **Size (Intensity**)
- **Intensity**: is the damage that the EQs caused. Or measure of the strength of ground shaking caused by an EQ (what happened to people & structures)
  - Qualitative scale (not based on measurements)
  - EQs have different intensities in different places It is wrong to refer to the intensity of an earthquake; it is necessary to state the intensity in, say, Los Angeles, or 'maximum intensity'
- **Intensity scales have 2 major disadvantages:**
  1. no use for EQs under the oceans
  2. no use for uninhabited areas. Even in inhabited areas, building standards vary in different areas, so earthquake effects are different
- To overcome the problems in measuring the size of EQs, a different way of measuring EQs size, using instruments, is often used instead of intensity
- **Magnitude**: measure of amount of seismic energy released by EQs, so it is a quantitative scale
  - **The scale of magnitude** is the Richter scale
  - **The Richter magnitude**: calculated by first measuring the size of the largest ground motion recorded by seismometer,
  - **Seismometer:** a sensitive instrument that detects ground movements produced by EQs
  - The closer the seismometer is to the EQs, the larger the ground motion will be
  - The sizes of EQs vary enormously: differ by 1000s or millions. so the Richter scale is based on 10^n (increase n by 1 = 10 times max. ground motion & 40 times seismic energy released)

EXAMPLE What increase in the maximum ground motion, & the energy released is involved between an EQ that measures 6.1 on the Richter scale or 8.1?

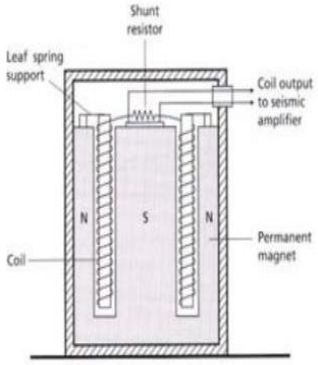
8.1 – 6.1 = 2 magnetude
Ground motion = 10^2 = 100 times
Energy released = 40^2 = 1600

STRESS & STRAIN

- How waves propagate in Earth? Seismic waves are elastic waves with energy converted from elastic to kinetic & vice versa
- **Elastic deformation:** Deformed caused by an applied force. Return to it's original shape when the force is removed
- Beyond elastic limit deformation permanent(plastic)
- **Stress**: Longitudinal stress (F/A) Force per area
- **Shear stress (τ)**: parallel to the surface (N/m^2)
- **Strain:** measure of deformation of material
- **Hooke's Law:** is the relationship between stress & strain, describes the extension of a spring (force)

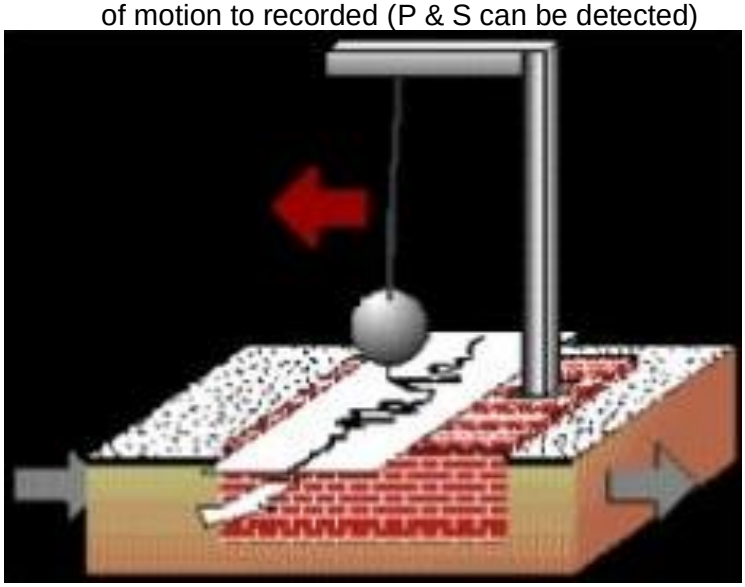
SEISMIC DETECTORS

- **Electromagnetic detection (geophones):** On land, the surface moves as a P-wave or S-wave arrives. Generally reflected signals arrive at steep angles of incidence. Thus P-waves produce surface motion that is dominantly vertical
  - ➢ geophone measure ground motion by converting motion into electrical signals
  - ➢ Most geophones measure a single component (vertical), multiple component sometimes used



Geophones are manufactured to detect a particular frequency band. This should match the seismic source being used in a particular survey

- **Mechanical seismometer:** Measure lower frequencies than geophones. Use a stationary mass. Measures motion of the Earth relative to the mass. Can measure vertical or horizontal motion
  - ➢ For EQs studies a more permanent installation is usually required
  - ➢ 3 components are recorded & the sensor is tuned to detect lower frequencies
  - ➢ Often the seismometer is placed in a shallow vault to minimize wind & other forms of noise.
  - ➢ can also be deployed in the deep ocean (Ocean bottom seismometers – OBS) & are dropped to the seafloor from a ship
  - ➢ Coupling with the seafloor allows 3 components of motion to recorded (P & S can be detected)



- **Accelerometers**
- **Hydrophones**: Only sensitive to pressure changes so only P-waves detected
  - ➢ Used in marine surveys

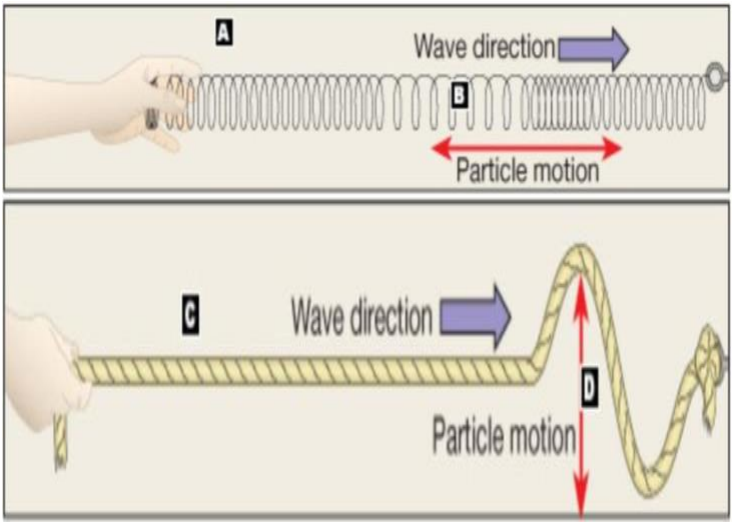
PROBLEMS

From Foundation Of Earth Science

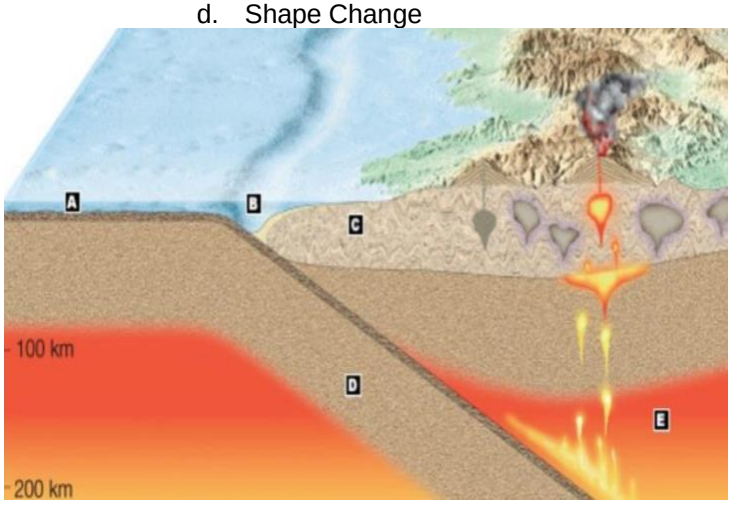
1. **The energy released by EQ travels in vibrations called** ____ _____ (SEISMIC WAVES)
2. **A break in a mass of rock along which movement occurs is called** _____ (A FAULT)
3. **The location beneath the earth's surface where an EQ start is called** _____ (FOCUS or HYPOCENTER)
4. **Types of waves from EQ that are longitudinal waves similar to sound waves that can travel through solids & liquids are called** _____ **waves** (P OR PRIMARY)
5. **The observations of intensity of shaking & damage done by EQs is done using** _____ **scale** (MERCALLI)
6. **What are 3 ways stress affect rocks** (PUSH THEM TOGETHER BY COMPRESSIONAL FORCES, PULL THEM APART BY TENSIONAL FORCES, PUSH THEM IN DIFFERENT DIRECTIONS BY SHEAR STRESS)
7. **Stress from moving tectonic plates produces** _____ **&** ____ (FAULTS, FOLDS)
8. **Characteristics of a fault** (A BREAK IN A MASS OF ROCK WHERE MOVEMENT OCCURS & MAY OCCUR ALONG PLATE BOUNDARIES)
9. **Characteristics of a fold** (BEND IN LAYERS OF ROCK WHERE ROCKS SQUEEZED BUT DO NOT BREAK)
10. **The location on earth's surface directly above the focus is called** _____ (THE EPICENTER)
11. **Characteristics of P-waves** (LONGITUDINAL, SIMILAR TO SOUND WAVES, CHARACTERISTIC BY VIBRATIONS PARALLEL TO THE PROPAGATION DIRECTION OF WAVE SO IT FASTEST, CAN TRAVEL THROUGH BOTH SOLID & LIQUIDS)
12. **Characteristics of S-waves** (TRANSVERSE, CANNOT TRAVEL THROUGH LIQUID)
13. **Characteristics of surface waves** (SLOWEST MOVING TYPE, DEVELOPS WHEN SEISMIC WAVES REACH THE SURFACE & PRODUCE GREATER GROUND MOVEMENT & GREATER DAMAGE)
14. **The 1st seismic waves to be detected at a distance are** ____ **waves** (P WAVES)
15. **What device is used by geologist to detect & measure seismic waves** (SEISMOGRAPH)
16. **Most EQ are concentrated along** _____ _____ (PLATE BOUNDARIES)
17. **The fastest type of EQ waves is** _____ (P WAVES)
18. **What is the earthquake?** (UNPREDICTABLE PHENOMENA, & IS SUDDEN RELEASE OF ENERGY IN THE EARTH INTERIOR IN THE FORM OF ACOUSTIC OR SEISMIC WAVES WHICH CAUSE GROUND VIBRATION ON THE SURFACE (if energy exceeds physical limits: stress & phase transition limits))
19. **What is the STRESS?** (THE FORCES OF DEFORMATION ACTING ON THE ROCKS OF CRUST)
20. **True or False. All EQ occur along fault associated with plate boundaries** (F)
21. **Energy released from an earthquake event is mostly in the form of** (Seismic or Acoustic waves)
22. **True or False. After rupture occurs along a fault, rocks continue to deform indefinitely from the release of energy** (F)
23. **True or False. Earth's crust has been uplifted several times** (T)
24. **True or False. Most of the motion along faults can be explained by Plate Tectonics** (T)

25. **Who contributed greatly to our understanding of the mechanism of earthquake generation by proposing the Elastic Rebound Theory?** (Reid)
26. **Most EQs are caused by** (slippage along a fault)
27. **Major earthquakes are often preceded by a series of small vibrations called _____** (Foreshocks)
28. **EQ waves cannot be transmitted via fluids?** (S wave)
29. **EQ body waves are divided into 2 types called** (primary or P-waves & secondary or S-waves)
30. **Body waves move through the interior of Earth** (P)
31. **True of False. Fluids cannot transmit P waves** (F)
32. **P arrive at a recording station after S waves** (F)
33. **Instrument used to record EQ is ____** (Seismograph)
34. **Which type of seismic wave typically causes the most damage to structural foundations** (Surface)
35. **P waves travel at a constant velocity in Earth** (F)
36. **P waves can be compared to the interaction between air & vocal cords to produce sound** (T)
37. **An earthquake with a magnitude of 6.5 releases about _____ times more energy than one with a magnitude of 5.5** (around 32 times)
38. **Choice The Correct Answer in the following**
    - **The _____ is based on the amplitude of the largest seismic wave recorded on a seismogram.**
        1. Dynamic scale
        2. **Richter scale**
        3. Moment magnitude
        4. Modified Mercalli Intensity Scale
    - **The epicenter of an EQ is located using the distances from a minimum of __ seismic stations**
        1. **Three**
        2. Four
        3. Five
        4. Six
        5. Seven
    - **The farther a station is from EQ, the greater the difference in arrival times of the P & S waves**
        1. False
        2. **True**
        - NOTE. The difference in arrival times are used to determine the distance to epicenter
    - **The moment magnitude of EQ is derived from the amount of displacement that occurs along a fault**
        1. False
        2. **True**
        - NOTE. Rock strength, fault area of the, & the displacement are all part of the calculation
    - **The difference in _____ of P & S waves provides a method for determining the epicenter of EQ**
        1. Sizes
        2. Foci
        3. **Velocities**
        4. Modes of travel
        5. Magnitudes
        6. Acceleration
    - **Distribution of EQ epicenters are correlated with**
        1. Coastlines
        2. **Plate boundaries**
        3. Major cities
        4. Continental interiors
    - **Which answer best describes the number of great earthquakes that occur annually?**
        1. 10
        2. **1**
        3. 0
        4. 1000
    - **The Richter scale expresses the damage done using an increasing scale of Roman numerals**
        1. **False**
        2. True
        - The Mercalli Intensity Scale used
    - **Intensity of an EQ event is determined by**
        1. Population density
        2. Building design and codes
        3. The Richter scale
        4. **1, & 2**
        5. All of the above
    - **No reliable method of short-range earthquake prediction has yet been devised.**
        1. **True**
        2. False
    - **Structure damage is the result of (determined by)**
        1. Structure rests upon (foundation/bedrock)
        2. Duration of vibrations & ground shaking
        3. Design of the structure
        4. Intensity of the earthquake
        5. **All of the above**
    - **To mitigate the hazard in EQ-prone areas?**
        1. Updated Uniform Building Codes
        2. Prohibit anyone from living near an earthquake
        3. Better land-use planning
        4. **All of the above**
    - **Current tsunami systems**
        1. Include seismic observatories
        2. Make use of existing tidal gauges
        3. Exist all around the world
        4. **Both1 &. 2**
        5. All of the above
    - **Soft & loose lake bed sediments decrease the strength & intensity of earthquake waves**
        1. **False**
        2. True
    - **Locked segments & sudden large EQ along San Andreas Fault provide examples of fault creep**
        1. **False (creep is slow, gradual displacement)**
        2. True
    - **A tsunami is a**
        1. Wind-generated wave
        2. Tidal wave
        3. **Waves created by a large displacement in ocean**
        4. Special shrimp in Japanese hydrothermal vents
        5. All of the above
    - **Long-range EQ forecasts are based on the premise that earthquakes are repetitive**
        1. **True**
        2. False
        - NOTE. After EQ, stress & strain will start to build up along the fault plane again
    - **Most of our knowledge of Earth's interior comes from the study of**
        1. **Seismic waves**
        2. Rocks
        3. Volcanoes
    - **Compressional wave motion is achieved by**
        1. **Change in volume**
        2. Change in shape
        3. Change in state
    - **Differences in density & elastic properties of rock greatly influence velocity of seismic waves**
        1. **True**
        2. False
        - *seismic waves faster in denser rock*

- **With increasing distance from the focus, energy from a quake is**
  1. Disappears within a few miles
  2. Heats up
  3. Doubles in strength
  4. None of the above
- **Which of the following events are sometimes associated with tsunamis?**
  1. Meteorite impacts
  2. Volcanic eruptions
  3. Earthquakes
  4. Submarine landslides
  5. All of the above
- **To locate an epicenter, the distance from 3 or more different seismic stations must be known**
  1. True
  2. False
- **Type of seismic wave propagates by "shaking" the particles of the material it is moving through at right angles to overall direction of movement**
  1. S waves
  2. Surface waves
  3. P waves
- **The vibration by the rapid release of energy is**
  1. Liquefaction
  2. Fault
  3. Earthquake
  4. Focus
  5. Discontinuity
- **The 2 types of seismic waves generated by the slippage of a rock mass are**
  1. P & surface waves
  2. Body & secondary waves
  3. P & S waves
  4. Body & surface waves
- **The method used to determine the epicenter of an earthquake is called**
  1. Circulation
  2. Circumvention
  3. Time travel
  4. Triangulation
- **The mantle is solid because both P & S waves travel through it**
  1. True (S waves cannot travel through fluids)
  2. False
- The adjustments of materials that follow a major EQ often generate smaller earthquakes called
  1. Aftershocks
  2. Foreshocks
  3. Tremors
  4. Body waves
  5. Surface waves
- **Most earthquakes occur along coastlines.**
  1. True
  2. False
- **Earthquakes with a Richter magnitude less than 8 are usually not felt by humans**
  1. True
  2. False (8 would be a major earthquake)
- **Large fractures in Earth along which movement occurs or has occurred in the past are called**
  1. Slabs
  2. Slips
  3. Earthquakes
  4. Faults
  5. Foci
- **Intensity is a measure of degree of shaking in a location determined by the amount of damage**
  1. True
  2. False
- **EQs produced by rapid release of elastic energy**
  1. True
  2. False (Energy released sudden rupture of rocks)
- **The type of plate boundary where plates move apart, resulting in upwelling of material to create new seafloor, is _____ boundary**
  1. Transitional
  2. Convergent
  3. Divergent
  4. Transform
- **During oceanic-continental convergence, a _____ is often produced adjacent to the zone of subduction**
  1. Deep-ocean terrace
  2. Deep-ocean trench
  3. Divergent boundary
  4. Deep-ocean ridge
  5. Transform fault
- **Transform faults can join 2 segments of MOR**
  1. True
  2. False

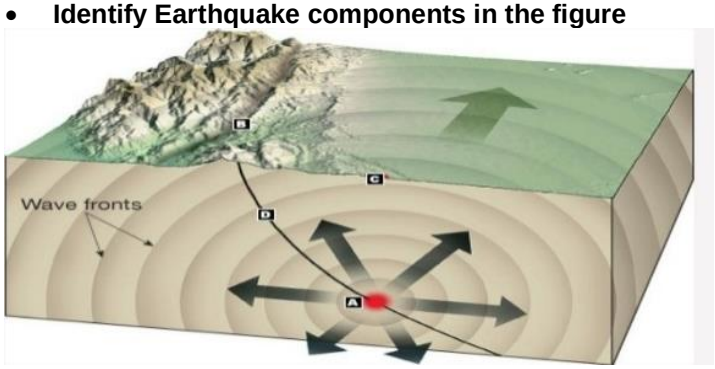


a. P-wave (Primary Wave)
b. Volume Change
c. S-Wave (Secondary Wave)
d. Shape Change

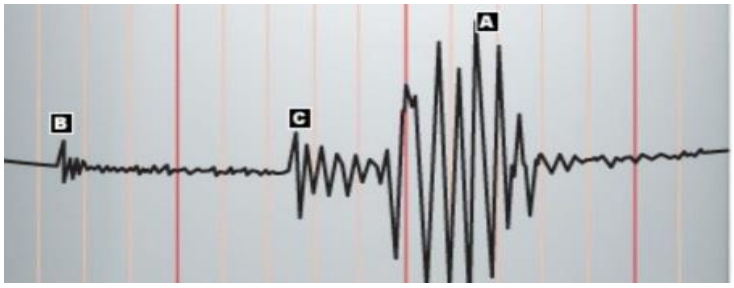


A. Oceanic Crust
B. Trench
C. Continental Lithosphere
D. Subducting Oceanic Lithosphere
E. Asthenosphere

- **Identify Earthquake components in the figure**

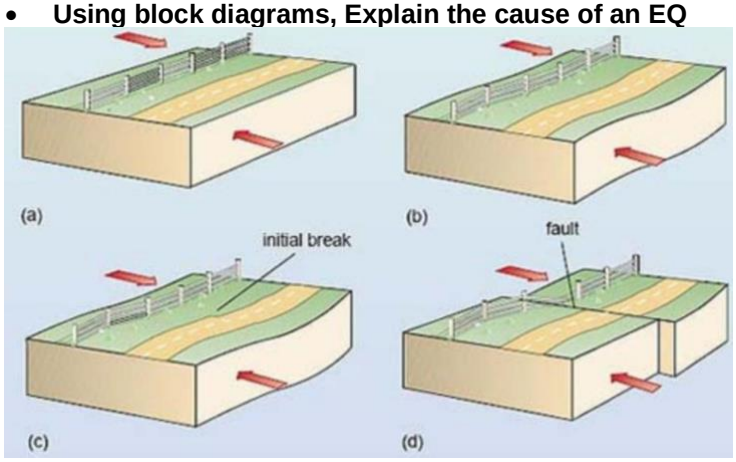


A: Focus (Hypocenter)
B: Fault Scrap
C: Epicenter
D: Fault Plane



A. Surface
B. P-wave (primary)
C. S-wave (secondary)

- **Using block diagrams, Explain the cause of an EQ**



A. Part of the Earth where forces (arrows) are trying to move the rock in opposite directions.
B. Before a fault breaks, the rocks stretch.
C. When the distortion is enough to cause the rocks to break, the break starts at one point
D. The break spreads rapidly along the fault, releasing energy

- **In an aerial view (part of the San Andreas Fault)**
  1. **What is the evidence for a fault in this photo?**
  2. **What are the relative directions of motion of the blocks on either side of the fault?**

The rivers & roads displaced across the fault, which is the linear feature

TESTBANK

QUIZ: 2020

- **EQs caused by sudden movement (rupture) along a**
  1. Lakes & Dams
  2. Stresses
  3. Fault plane
  4. Mountains
- **Earthquakes are concentrated along**
  1. Countries
  2. Plate Boundaries
  3. Hotspots
  4. Convergent Plates
- **Earthquakes are characterized by _____ that cause ground shaking & movement, which can result in significant damage**
  1. Magnitude
  2. Intensity
  3. Richter
  4. Seismic waves
- **Seismic & coastal hazards combine in formation of**
  1. Destructive Plates
  2. Divergent Plates
  3. Tsunami's
  4. Mid oceanic Ridge
- **An earthquake starts at the earthquake _____ which is the fault zone along which the earthquake slips**
  1. Focus
  2. Epicenter
  3. Hypocenter
  4. Hypocenter & focus
  5. 1+3
- **Earthquakes are located using a record of the earth vibration called a _____**
  1. Seismogram
  2. Seismograph
  3. Receiver
  4. Antina Richter
- **The most widely accepted indicators of the size of an earthquake are its _____ & _____**
  1. Focus & epicenter
  2. Epicenter & hypocenter
  3. Magnitude & intensity
  4. Richter & Mercali
- **The nature of earthquakes can be explained by means of _____**
  1. Plate tectonic theory
  2. Conviction Flow
  3. Mid oceanic Ridge
  4. Focus & Epicenter
- **Strain is a _____**
  1. Normalized Measure of Deformation of Material
  2. Deformed Caused by an Applied force
  3. The force is Removed
  4. Longitudinal Stress (F/A)
  5. Force per unit Area
  6. Shear stress
- **Surface waves are localized at the Earth's surface & can be divided into 2 types:**
  1. Rayleigh & Love waves
  2. P and S waves
  3. P & shear Waves
  4. S and shear Waves

SECOND EXAM 2020

- **Landslide is a**
  1. Rapid movement of earth materials down a slope, the materials ranging from huge boulders
  2. Rapid movement of earth materials up a slope, the materials ranging from huge boulders
  3. Both are Correct
  4. None of them
- **A large earthquake is frequently followed by a series of smaller earthquakes on the same fault**
  1. Aftershocks
  2. Beforeshocks
  3. Secondary Earthquakes
  4. Main Earthquakes
- **Earthquakes less than 70km deep are classified as**
  1. Shallow-focus
  2. Intermediate-focus
  3. Deep-focus
  4. Very Intermediate-Focus
- **At greater depths the rocks are very hot & under high pressure so they deform by**
  1. Flowing rather than breaking & faulting
  2. Faulting and fracturing
  3. Destructive
  4. None of the listed
- **Do the EQs occur everywhere, or only in the some parts of the Earth?**
  1. Everywhere but particularly at oceans
  2. Everywhere but particularly at continents
  3. Everywhere but particularly at plate boundaries
  4. Everywhere but particularly at MOR
- **Deep-focus of any EQ appears to be associated mainly with the _____**
  1. Mountains & Ocean trenches
  2. Mid oceanic Ridges
  3. Continental Volcanic arc
  4. Island arc Volcanos
- **The EQs are largely confined to specific areas of the Earth (_____)**
  1. Seismic zones
  2. Volcanic arc
  3. Mid oceanic Ridge
  4. Faults & Folds
- **The intensity of an EQ is referred to**
  1. Damage caused at a particular place by an EQ
  2. The area far of the focus on an earthquake
  3. Even the magnitude
  4. Cars destructive
- **The _____ is the amount of energy released by EQs, so it is a quantitative scale**
  1. Magnitude & Intensity
  2. Only the Intensity
  3. Magnitude
  4. Structures Damage
- **A seismometer is a/the _____**
  1. sensitive instrument that used to detect ground movements produced by an earthquake
  2. diagram describing an earthquake
  3. distance between an earthquake & focus
  4. focal depth

FINAL EXAM 2020

- **EQs are caused by movement (or rupture) along**
  1. Faults
  2. Tsunami
  3. Lakes
  4. Oceans
- **Earthquakes are concentrated along**
  1. Faults
  2. Plate boundaries
  3. Tsunami
  4. Intraplates
- **Earthquakes are rarely occurring as large**
  1. Intraplate earthquakes
  2. Plate Tectonic earthquakes
  3. Subduction earthquakes
  4. Mid oceanic ridge earthquakes
- **EQs characterized by ___ that cause ground shaking**
  1. Seismic waves
  2. Building destruction
  3. Magnitude & intensity scales
  4. Volcanic earthquakes
- **Liquefaction risk is**
  1. higher in high water saturation & fine sediments
  2. lower in high water saturation & finer sediments
  3. higher in low water saturation & finer sediments
  4. higher in high water saturation & coarse sediment
- **An example of man-induced Earthquakes**
  1. Both are correct
  2. Injection of fluids into rocks
  3. Mining
  4. The most is mining activity
- **Foci of natural EQs in Earth's Crust & Upper Mantle**
  1. Faults
  2. Streets
  3. Dams
  4. Liquefaction
- **The Harms & losses on human assets are caused by**
  1. Tectonic earthquakes
  2. Intra-plate earthquakes
  3. Tsunami
  4. Liquefaction
- **One of the following is from Earthquakes parameters**
  1. Geographic coordinates of epicenter (E)
  2. Fault plane
  3. Tsunami
  4. Focus
- **Seismogram is**
  1. Instrument for recording the earthquakes (if ground acceleration is measured-accelerograph)
  2. Earthquake record (in case of ground acceleration recording– the accelerogram)
  3. Both are correct
  4. None of the mentioned are correct

- **What are the Collapse earthquakes**
  - are small EQs occurring in the regions of underground caverns & mines (The immediate cause of ground shaking is the collapse of the roof of the mine or cavern). Or in other words the collapse earthquakes is an EQ produced due to filling of the underground spaces
- **Identify the stress that caused the following deformation, & what is type of the deformation**
  1. Compressional Stress, Reverse fault
  2. Tensional Stress, Thrust fault
  3. Tensional Stress, Reverse fault
  4. Shear stress, strike-slip fault
- **Permanent Earth's surface vibration**
  1. Microseisms
  2. Megaseisms
  3. Vibroseisms
  4. Tsunami
- **How to locate an earthquake**
  - EQs located by epicenter (point on the surface right above the focus) by tangential method
  - Tangential method deals with separation in time of 1st arrival of the P- & S-waves correlates directly with the distance of EQ from the stations
  - Station: at least 3 stations are required to locate the EQ by drawing a circle with radius = distance between the epicenter & the station, & The intersection of the 3 circles is the epicenter
  - Calculation: Determine distance of EQ from 3 seismic stations by calculating S - P arrival times = distance in time, & plot them on travel-time graph, Intersection of circles gives location
- **What is the Elastic deformation**?
  - The change in length, volume, or shape of an object that have elastic behavior due to stress that is less than the elastic limit, & returns to its original size & shape after stress are removed
- **EQ with magnitude 3 produces _____ times greater maximum ground motion than EQ with 1 magnitude**
  1. 100 times (10*10)
  2. 10 times (10*1)
  3. 1000 times (10*10*10)
  4. 150 times (10*15)
- **Seismic hazards are related to**
  1. Risk sources (Causes)
  2. Emergency (Consequences)
  3. Earthquake prediction
  4. Earthquake impacts
- **Seismic risk are related to**
  5. Risk sources (Causes)
  6. Emergency (Consequences)
  7. Earthquake prediction
  8. Earthquake impacts

- **How can we decrease the seismic risk down?**

Is not possible to avoid or predict occurrence of EQ, or to eliminate presence of man & structure but it is possible to limit EQ effect (Vulnerability) carrying out adequate Risk Reduction Policies such as Design of buildings capable of EQs resistance, conduct studies to predict EQs in places where there is a possibility of EQs (i.e. Fault, Folds…), and so on

- **What is the historical earthquake?**

All known EQ foci occurring in the historical time basing on the analysis of written source

- **When did the earthquake has begun to become a problem for humans?**

If considered in relation with structures (since they started to build structures)

- **What is the focal depth?**

Is a vertical distance between the focus (hypocenter) & the epicenter

- **What is the Liquefaction Risk in seismology?**

Is a phenomenon in which the strength & stiffness of a soil is reduced by an EQ shaking or other rapid loading (in general the liquefaction is the secondary affect of an EQ)

- **The different between seismic hazard & risk**

Hazard: is a CAUSES (a Phenomena itself) & related to the risk sources, Occurrence of EQ of sufficient magnitude capable of causing damage to the structures

Risk: is a consequence or emergency of an EQ & related to the protected interests (potential economic, social & environmental consequences of hazardous events that may occur in a specified time)

- **What are the most accepted indicators of the size of an earthquake are?**

Magnitude & intensity

- **In the field of EQ, what does Strain mean**

Is the deformed in a given rock or body of rock that caused by Applied Force (stress over unit area)

- **Seismic (EQ) & coastal hazards combine in**

Tsunamis

- **The most important benefits of EQs**

Enable the Earth's interior research (crust, mantle, external core, & internal core) because S-wave cannot travel in the liquid state but P-wave do

- **EQs are located by epicenter (point on the surface of the earth right above the focus) how?**

by tangential method, by separation of 1st arrival time of P- & S-waves that correlates directly with the distance of EQ from the station in time unit & the distance can be graphed on travel-time curve

At least 3 stations are required to pin-point the location of an EQ by drawing a circle with radius = distance between the epicenter & the station & The point where the 3 circles intersection is the epicenter

Calculation: Determine distance of EQ from 3 seismic stations by calculating S – P arrival times = distance in time

- **Since EQ can't be controlled, & are relatively unpredictable, we must adjust to their impact. Could you please explain how to do that?**

  It is possible to limit EQ effect carrying out adequate Risk Reduction Policies such as

  1. buildings capable of EQs resistance
  2. conduct studies to predict EQs in places where there is a possibility of EQs (i.e. Fault, Folds…), لعدم البناء في تلك الاماكن

- **Based on your understanding of seismology, please identify the focal provinces?**

Focal provinces-zones: area where EQs foci concentrated & The boundary of focal provinces are defined as a boundary that surrounds:

1. all known EQ foci occurring in the historical time & case when they're evidence on prehistorical foci from the research of paleoseismicity
2. the region in which the EQ with the same characteristics of seismic regime occur
3. Region with the same geological, tectonic, & recent movements characteristics

- **What are the Earthquake parameters?**

1. Focal depth: vertical distance between focus or hypocenter & epicentre
2. Size of an earthquake (most common are magnetude, & intensity)
3. Geographic coordination of epicenter: epicentral distance (distance between epicentre & seismic stations)

- **Why are there earthquakes? Explain the earthquake mechanism?**

The relative movements of rocks along faults & near plate boundaries cause sudden energy released within the Earth in the form of acoustic waves (seismic waves) & this waves then transformed into the earth's surface in the formation of ground vibration or motion (EQ)

- the earth is elastic body, & Change in length volume, or shape of an object that have elastic behavior due to applied stress that is less than the elastic limit, & returns to its original size & shape after stress are removed & as return to its size & shape it release energy in the form of seismic waves

- **What is the Richter magnitude of EQ? & how we can calculate an earthquake magnitude?**

Magnitude is the measuring of released energy & doesn't related to epicentral distance or damage, We can calculate the magnitude by calculating amplitude (is the maximum amplitudes of P & S waves or height of the waves) that calculated by the amount of displacement that occurs along a fault (Rock strength, fault area, & the displacement are all part of the calculation) Mathematically we use the following equation

$$Ml = \log(A/A')$$