Plate Tectonics
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Week - 12
Lecture – 60
Global Positioning System (GPS) and Plate Tectonics

So, ok friends, welcome to this last class of plate tectonics that is called the global positioning system and plate tectonics. So, far we have discussed different type of plate motion. The plates are moving with respect to each other, convergent, divergent, conservative plate margins are there. And during their movement, they create some faults and different kind of faults are there and due to effect of faults some landslides are there. So, that means, this plate tectonics its effect and its application that we have already completed. And at this stage, we are going to discuss about how the plate motion is measured.

So, to substantiate it, we are talking about the global positioning system. So, global positioning system you all have with you that is the your mobile phone it is very well known GPS system, it is established there. Anyone you can ask for this live location in WhatsApp or something like that. So, this global positioning system that means, your position in the globe anywhere in terms of latitude and longitude and also in altitude.

So, how the global positioning system works and how it is used to determine the plate motion we will discuss in this present class. So, before going to talk about this plate tectonics and relating it to this GPS system or the global positioning system. So, we should know what is exactly a GPS. So, GPS, a system by which signals are sent from satellites, so that means, it is a satellite-based system that means, you have heard different satellites we have the ionosphere above. So, those satellites are totally monitoring our movement.

So, now imagine you are on the earth surface and the satellite is thousands of kilometer away from you and it is watching your movement, your activity, your day to day, that means, activity where you are going, how much time you are spending with someone so like that. So, that is why it is a satellite-based system and used to show the position of someone or somebody on the surface of this earth. So now, imagine there are 3 satellites for example, and from 3 satellites the different distance that means, it is calculated for

example, my mobile phone is there it is in communication with this GPS system. so, that means, this GPS system it is measuring my distance with respect to that satellite and other satellite it is also measuring its distance from me, the third satellite it is also measuring its distance from me. So, now the 3 distance if I am putting in different circle so, the junction is my location at the similar way that we are determining the earthquake epicentral distance from this graph or so.

So, similarly this is the global positioning system and these are the satellites and the satellites they are 24 and 7 they are sending their signals and that signal is received by receiver on the ground station and from there this latitude, longitude, altitude is calculated. And GPS is a system made up of 3 parts. So, what are the 3 parts? First is the satellite part that we have already discussed then we have a ground station then third is the receiver that means, you the mobile phone users and it is the space based system satellite the space based system and it known where they are supposed to be at a given point of time because we have sent it. The satellite is totally controlled by us every each and every moment that means millisecond to microsecond we can control it. So, at a given point of time we know where my satellite is.

Then another is the ground station. So, it uses radar to make sure they are actually where we think they are and the third one is the receiver that is we the user and it is constantly listening for a signal from the satellites and GPS works by sending radio signals from the satellite to ground station. So, it is working based on the radio signals. So, once the receiver calculates its distance from 4 or more satellites and its location is exactly traced. So, that we do our location mapping when we go for field work earlier we are using this back bearing that means, 3 different places we just draw the back bearing and finally, we locate our self on the top of it.

And the same technology it is here if it is more than 3 or 3 satellites if they are merging their points so that means, the precisely they are locating me. So, how precise they can locate me that depends upon the this interaction. So, data from the GPS it is reported in 3 components. So, first component is the latitude. So, here this is the north south direction that is the latitude.

Then we have east west direction that is the longitude. Then up down movement that is called vertical or the height. So, this 3 data that can be retrieved from a GPS latitude, longitude and altitude. And GPS measurements are firmly anchored in the bedrock and move along the tectonic plate. Now slightly we are introducing this GPS system to the tectonic plate.

So, we have different GPS stations and those GPS stations they are firmly on the bedrocks. Because if it is the loose material there will be chances of going down. So, that is landslide. So, people are monitoring landslide later part of this class we will talk about the uses or other uses of GPS. So, on this bedrock which is firm we are putting our GPS there because once the plate is moving this rock is also moving and it is interacting with the satellite system there.

So, we can say at what point of time what is the latitude, longitude and altitude, at other point of time what is the long and altitude. So, in this way we can calculate the what is the or what is the distance lag and what is the direction in which of the place particularly the place of observation is moving. So, as a GPS station moves its position changes through time and once the position changes through time and GPS station as we have anchored it to this tectonic plate or the crust so that means the system is moving. So, here there is an example and data taken from this United States Naval observation system. So, here this is the latitudinal change of a point, this is longitudinal change of a point and this is the altitudinal change of a point.

So, with time different years starting from 1998 to 2013 a particular point how it change its latitude, its longitude and its attitude it is very soon here and nothing these are the GPS measurement. And in the GPS measurement, you probably have seen number of maps you will see these arrows are pointing towards different directions. So, these directions are nothing the direction of movement. So, two adjacent plate for example, if you see this white color it is represented as a mid-oceanic ridge system and in this way this plate is moving this direction and this plate is moving this direction. So, now imagine this mid-oceanic ridge system, we know it is a divergent plate margin.

So, two plates they are moving two different direction. And this size of this arrow or this length of this arrow that indicate the rate of movement that means how fast it is moving. So, longer the arrow the faster the movement is and if you remember whenever talking about this Euler's pole of rotation or Euler's pole in application in plate movement. We are finding that the near to pole the movement is minimum and at the Euler's equator the movement is maximum. So, this length of this arrow that means it is indicating it is the region for that particular plate the Euler's equator.

So, as each plate rotates about a pole that is the Euler's pole and each plate also has a different speed the faster the stations are from this pole or the rotation the bigger speed of the GPS station. So, that means once the places of GPS stations are away from this pole of rotation they will record larger movement or the larger arrows can be demarcated

there. So, this can be understood by this very simple example. Suppose you are sitting on this ferris wheel which is rotating counterclockwise in this particular figure with the angular speed of W and here the speed of any point in the it is the multiplication between distance and W.

So, dW is the speed. So, what is d? This is the distance d. Similarly here in the tectonic plate we have three recording stations or GPS stations and this is the Euler's pole in the pole of rotation of this axis of rotation which is cross cutting in the surface. So, now one is very close to this pole another is some far away and the third is the farthest. So, now see the movement or the speed or the linear speed is equal to d into W. So, here this is now you see how much is.

So, it is moving at a faster speed then relatively slower and it is relatively slower and here it will be 0. So, this movement how we record it? So, this movement it is the absolute plate motion. So, if you remember earlier class when we were talking about this there are two types of plate motion one is absolute motion another is relative motion. Relative motion we have already discussed in the class. So, this GPS whatever the data it gives to you it is the absolute plate motion that is 5 centimeter per year that means it is absolute motion 5 centimeter per year.

And this system or this GPS device which that means we are using for this plate tectonics study it is a set of around that is 31 satellites. And it is placed in 6 different orbital planes and inclination about it is 55 degree and elevation you see how far they are from this earth system. And they are producing or they are giving you the absolute plate motion it is the plate motion with respect to earth's deeper interior. So, deeper interior means that is the center of this earth and this is the fixed reference system is there. Absolute plate motion describe the motion of this plate relative to a fixed reference system regarded as the fixed such as the earth mesosphere or at the center of this earth.

So, with respect to center of the earth a particular place house in which direction it is moving that is the fixed point it is the center of this earth. If you remember when we were talking about this Euler's pole, the Euler's axis it is passing through the center of this earth, is not it? So that means from miles up that means from kilometers or thousands of kilometer away from the surface this GPS is monitoring and from this miles up in space location the ground can be determined with much precision. So how precise will be that depends upon this receiver system, how strong your receiver system is. More high tech receivers can configure out with a few inches of precision. It means very precisely it can detect where exactly you are.

And the GPS not only used for plate tectonics are determining the plate motion other than this plate motion particularly they are using in this fields like this transportation, taxi, bike you know that modern days everywhere any locomotive system it is using this GPS system. Then communication or live location, sending live location to friend, then other locations. So all these systems they are using the GPS device. And anyway so GPS is giving us a velocity so that means a speed and a direction in which direction this plate is moving at what rate it is moving. And the GPS velocity vectors point the direction that GPS stations move at the ground and as it is anchored.

And the length of the velocity vector correspond to the rate of motion. GPS velocity vectors provide useful information for how the earth's crust deforms in different tectonic setting. For example across this tectonic setting divergent system now you see the GPS velocity vector are opposite to each other. And here you see around this Mariana system here this plate is moving this way and these plates are moving in this so this is a converging system. Similarly at this plate that is called this transform system.

So that means different tectonic settings the GPS velocity are different and the direction are also different. So by installing high accuracy GPS receivers on each tectonic plate scientist can record the speed and direction that each plate is travelling in. Once installed these receivers can operate for decades allowing scientist to analyze any changes in the direction of each plates motion. And geodesy it is the science of measuring this earth's shape and position on it allows the measurement of plate motion directly using GPS. Now you see world over there are number of GPS stations and they are monitoring these plate motions and some of these more precisely some landslides are being monitored, some faults are being monitored.

So that means GPS has tremendous use and the distance between the satellite and the station is recorded by the GPS over time these distance changes slightly due to the tectonic plate moves. And by recording the time it takes for the ground station to move a given distance plate motion is determined. So in which direction the plate moving at what rate is moving. So you can see here how this Himalayan system is totally instrumented and this GPS motion in the direction it is showing that this part the Tibetan plataeu Plate 2 it is moving in this direction and here the Indian Plate is moving this direction. So these are the way how the GPS can be used to determine the plate motion.

And not only the plates some fault lines are being monitored continuously. For example, if you see this is the most coveted fault or decorated fault that is called San

Andreas fault and the GPS motion you can see here this side this is movement is very fast and here if you see the right side of this fault this motion is very less compared to this left-hand side. So that means the left-hand side it is moving faster as compared to the right-hand side. So this is San-Andreas fault and the GPS stations are here. Similarly in India we have MFT, MBT, MCT this prominent thrust in the Himalayas.

So their rate of convergence along different thrusts that is being monitored by different GPS stations. And apart from this fault system landslides are being measured, landslides are being monitored. So if you see here these are the symbol the first survey and this black dots for the second survey. Now what you see from first to second there is a shift. Similarly from first to second there is a shift and here from first to second there is a shift.

So as it is shifting towards west for example in this particular figure so it should have acted like this. So a black dot should here but now the black dot is here. So that means it is indicating there is a subsidence. So both latitude longitude wise there is a change and altitude wise there is a change. So this is the way how scientists are monitoring the landslides and the landslides which are the GPS stations are moving very fast they are predicting that there could be a very near future there could be a landslide.

So this early warning system how they are that means particularly in case of landslides they are based on this GPS system. And in the landslides you see different GPS stations they are installed and the GPS movement is shown in the arrows. And in this landslides the GPS stations are installed by this concrete structure because you cannot put a GPS on this boulder which can topple down and roll to this valley. So that is why on this landslides area or particularly landslides on which GPS station should be established a concrete station is created at very small concrete station is there and which the GPS is being placed. Similarly this is another landslide and or it is the hill slope.

On the hill slope this is the GPS it is installed and its movement with time it is being monitored 24 into 7 and the rate of motion and the direction of motion that can be monitored and the change of position with time it is says the rate of motion and the direction in which it is moving. So in this way the landslides are monitored the fault systems are monitored the tectonic plate movement are monitored. So this is all about your GPS and plate tectonics and thank you very much. Thank you again.