Crustal movement and plate motion deduced from GPS observation

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1.Concept of 'plate' taught in high school earth science course

Plate motion as the driving force of the active tectonism is taught in high school earth science course. Studying direct observation of the plate motion is essential in order to get the concrete image of the current plate motion rather than palaeo-motion as observed by geomagnetic anomaly pattern etc. GPS(Global Positioning System) technique is common now for this purpose for continuous observation with the same accuracy all over the world. The authors, therefore, propose that the process, technique and interpretation of the direct observation of plate motion by GPS are to be included in the earth science course.

2.GPS

GPS is a positioning system by use of satellites arranged on the orbit with an altitude of about 20000km. The system was developed since 1973 by U.S. Navy and Air Forces and became in operation formally for worldwide precise 3-D positioning in Dec.'93. It is originally positioning system for maritime navigation and aviation. However, the positioning technique is now used now for more advanced purposes such as onland navigation for automobiles, a cellular phone with GPS, etc. It has also been remarked since the early stage of development that the system was available for precise baseline length measurement within an accuracy of a couple of centimetres by interferometry of the transmitted carrier of the GPS system.

3.GPS Earth Observation Network operated by Geographical Survey Institute Japan

Geographical Survey Institute Japan(GSI) has established GPS Earth Observation Network(GEONET) which consists of more than 1000 GPS stations with 25km in spacing on the Japanese islands in order to monitor the regional crustal movement and to establish the reference site for the onland geodetic survey. These observation data from all the stations are transmitted to the GSI headquarters, analysed immediately and the baseline length change among the stations are calculated. These results are visualised into the baseline length change diagrams, vector diagrams showing horizontal displacement of the GPS stations for the past year, etc. and are finally open through the internet. Some of these data show clearly crustal distortion in the plate convergence region in northeast Japan, relative motion between the Philippine Sea plate and Eurasia plate, etc.

4.Proposed curriculum to study the current plate motion

The following is a possible curriculum to study the current plate motion based on the GPS observation and its relation to the seismicity and volcanic activity in and around Japan for high school earth science course.

1)Study the principle of GPS and its application to the baseline length measurement.

2)Diagrams showing the baseline length change for the past year in some areas(e.g. Northeast Japan, Central Japan, Ryukyu Islands, etc.) are presented. Students read them and get the rate of the baseline length change for each diagram.

3)Study the baseline length change rate among the stations based on these data, and discuss the characteristics, regional difference, etc. Study also the position change for the past year of each station based on the observed baseline length change.

4)Next, the position change data at each station is presented as the basic data to be processed for further analysis.

5)Draw a vector diagram based on the data in order to extract the characteristics of the deformation at each station.

6)Discuss the above result and the relation with the specific topographic feature around the station such as a trench and a trough, the relation with a deep seismicity, etc.

It is also effective to download the data from the GPS station nearby from the GSI web site during the curriculum. This makes the students feel vividly the dynamic motion of the land where they live although the absolute rate is so small. In addition to this, understanding the application of the GPS technology to the earth sciences is to be included into the curriculum.