GEOMETRICAL INTERPRETATION OF PLATE MOTIONS IN JAPAN DURING JUNE 2008 AND MARCH 2011 EARTHQUAKES

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Keywords: Pacific Ring of Fire. Intra Plate. Partial Displacement. Convergent Tectonics. Non-Tectonic

ABSTRACT

History of multiple plate and intra plate tectonics have been continuously recorded in the region of Japan by the network of GPS stations called GEONET since 1979. The intra plate tectonics resulted in the June 14, 2008 and the plate tectonics resulted in the March 11, 2011 earthquakes have been studied in this research using the daily recorded accurate temporal 3-D geodetic coordinates of the GPS stations around the epicenters. Average vectors (both in magnitude and direction) of motions or horizontal partial displacements are derived from the partial displacements calculated for every epoch of time at the stations. The average directions all averaged again to determine the general direction of motion of the plate. The average vectors versus the corresponding epochs of time make up a time series containing the history of motion of the plate in a selected period of motion. For the intra plate tectonics resulting June 14, 2008 earthquake, two time series are used. One is built up using data from the stations located in the west bank and the other is built up using the data from the stations located in the east bank of the corresponding epicenter occurred inland Japan into the Pacific ring of fire. The time series used to plot the intra plate tectonics. It was a convergent tectonics with co-seismic horizontal displacement of about 1.5 m and 2 m vertical displacement. The famous March 11, 2011 earthquake was the effect of inter plate tectonics caused co-seismic displacement of 5 m in horizontal direction and 1 m in vertical direction across the Japanese trench and the disastrous tsunami afterwards.

INTRODUCTION

The tectonic phenomena happening in the region of Japan, is the North Pacific (NP) oceanic plate sub ducting underneath the North American (NA) plate, [Sagiya, T. 2004], creating what is called the Japanese Trench stretching across the Japan. These tectonics are continuously monitored by almost 1200 GPS stations the network of which is called the GEONET, [Kamiyama, M. et al., 2012]. The temporal positions of the stations are permanently observed and recorded at each station into files against the time of observations. The type of data processed is F3 [Kamiyama, M. et al. 2012, Djamour, Y., et al., 2010], the most accurate absolute 3-D coordinates given in ITRF05 coordinates system by Geographical Survey

Institute (GSI) of Japan. By the new analysis strategy of GEONET, [Hatanaka, Y. et al. 2003], the data is corrected for some non-tectonic periodic variations such as solid earth tide, pole tide, sub-daily polar motion, ocean loading tide, site phase characteristics, tropospheric estimation using the software BERNESE Ver. 5.

What we are going to investigate here is the tectonic motions in the region causing the June 14, 2008 earthquake. What makes it interesting is that, the epicenter of the earthquake is located inland Japan on the what is called the Pacific ring of fire [http://], hence, it is an intra plate earthquake. Also, motions causing the March 11, 2011 earthquake are studied in this research.

THE METHOD OF INVESTIGATION

Examination of the data (time series) collected in the stations show that the temporal changes of the coordinates, i.e., the partial horizontal displacements or motions (computed in local E-N coordinates systems) at a station is almost steady in time and the motion is aligned in a horizontal direction almost parallel with the directions of motions in the neighboring stations, but the speed of motion may be different in magnitude from place to place throughout the region. This is the kind of behavior peculiar to the plate tectonics as implied by the physics of the phenomena. To represent the motion of the NA plate as a whole in the Japan region and in a given epoch of time, all partial displacements calculated for that epoch in the stations are averaged both in magnitudes and in directions. Then, the average directions in different epochs are averaged again to determine the general direction along which the plate as a whole moves in time. Having this general direction determined, the partial displacement vectors at given epochs all are mapped along this direction to accomplish the history of motion of the plate, i.e., to build up the time series giving the partial displacement vectors of the plate versus epochs of time (in the period of motion) all aligned in the general direction of motion already determined. It is worth noting here that, this time series is valid in a period of time in that the plate does not change the course of its motion. This has been taken into account in the case of June 14, 2008 earthquake, i.e., two time series characterizing the motion of the plate is realized. One is the time series built up by taking into account the displacements at the GPS stations located in the west bank of the Pacific ring of fire containing the epicenter. the second time series is built up by taking the displacements occurred in the east bank of the epicenter.

Fig. 1 shows the partial horizontal displacements versus the epochs of time in the west bank, Fig. 1 a (time series 1), and the partial displacements versus the epochs of time in the east bank, Fig. 1 b (time series 2), of the assumed fault containing the June 14, 2008 earthquake epicenter, during the time interval of June 1 – June 25 2008. The time axes in the Figs are running in opposite directions, i.e., Fig. 1 b mirrors Fig. 1 a. The figures confirm that the tectonic is convergent.

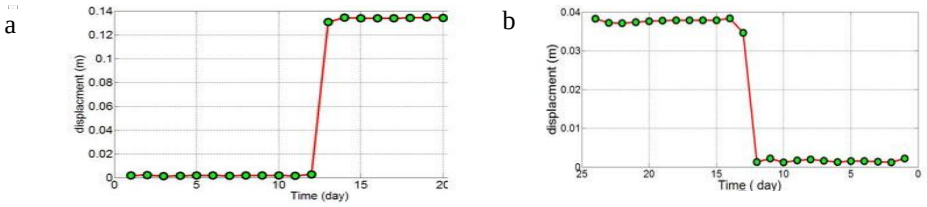

Figure. 1 a) Pre, co, and post seismic Partial horizontal displacements of the NA plate along the general direction or azimuth of **122.5°** during June 1 – June 25, 2008 **west bank** of June 14, 2008 earthquake epicenter. b) Pre , co, and post seismic Partial horizontal displacements of the plate occurred in the azimuth of **280°** at the same period in the **east bank** of the epicenter

Figs. 2 a and c show the vectors of horizontal displacements at the stations in the west and east bank of epicenter during the June 14, 2008 earthquake. All the motions extend towards the epicenter. The epicenter happened in the middle of Japan island implying a fault crossing the island (Fig. 2 b).

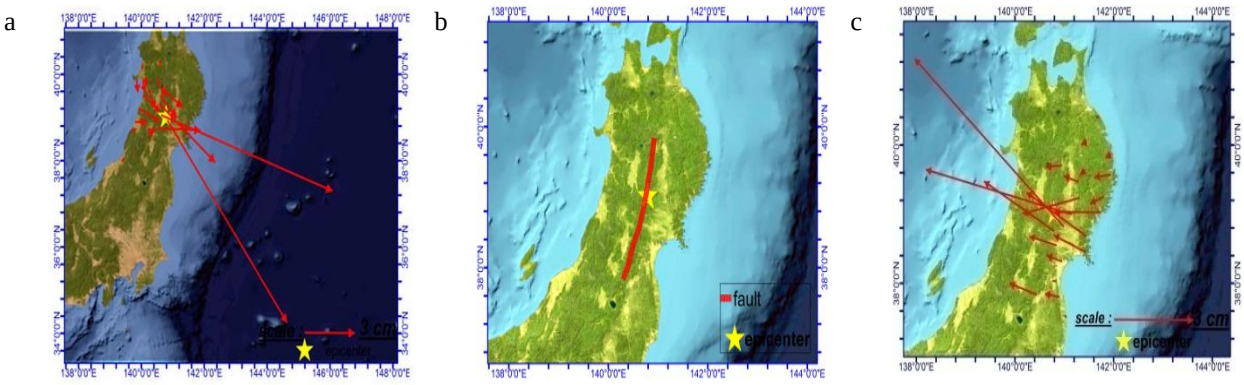

Figure. 2 a) Co-seismic NA plate motion in the west bank the 2008 earthquake epicenter. b) inland Japan part of Pacific ring of fire. c) Co-seismic NA plate motion in the east bank the 2008 earthquake epicenter

Fig. 3 shows the NA plate horizontal motion at different stations during the March 11, 2011 earthquake at west bank of the epicenter, [Sagiya, T. 2004]. All the motions extend towards the epicenters.

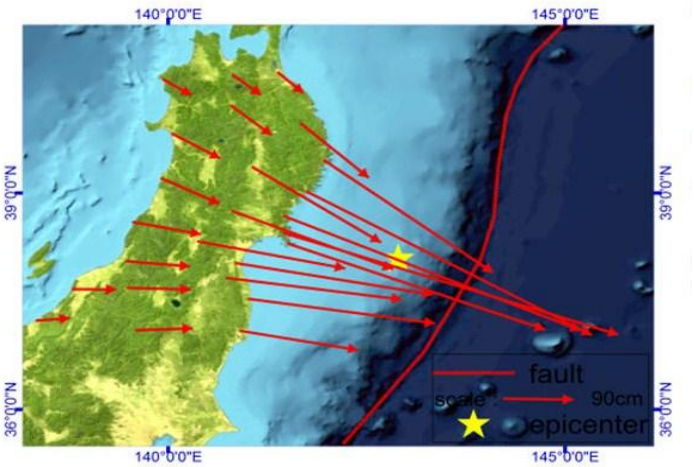

Figure. 3 Co-seismic motion of NA plate motion in the west bank of the 2011 earthquake epicenter

DISCUSSION AND CONCLUSION

As shown in the Fig. 2, the horizontal partial displacement close to epicenter on the day of June 14, 2008 earthquake grows to almost 1.5 m on the horizontal direction and 2 m (not shown on the map) in vertical direction. It seems that the June 14, 2008 earthquake was the effect caused by some tectonic activities happened inside the Pacific ring of fire, i.e., an intra plate tectonics. On the day of March 11, 2011 earthquake (Fig. 3), the horizontal displacement attains almost 5 m in horizontal direction and 1 m in the vertical direction close to the epicenter and across all Japanese Trench.

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