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IMPACT OF CLIMATE CHANGE ON CRUSTAL MOVEMENT IN THE NORTH-EAST INDIA: A SCIENTIFIC FIELD STUDY USING GLOBAL POSITIONING SYSTEM (GPS)

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ABSTRACT

The earth's crust is composed of number of plates which are moving relative to each other. Due to earth's movement, different plates possess different velocities. Scientists have discovered that there is a relationship between the climate change and crustal movement. According to them, the velocity of plates is accelerated up to twenty percent due to heavy rainfall. The North-East India is considered to be one of the world's heaviest rainy areas. It receives more than 300 cm of rainfall every year. This heavy rainfall in the North-East India should play a role in accelerating movement of the plate. But the above findings failed so far as the North-East India plate is concerned. We have done micro seismic study in this region for continuous four years (October, 2006 to February, 2011) with the help of Global Positioning System (GPS). In this article we have compared the velocity of Indian-Australian plate as well as of North-East India region. All are analysed here.

Key words: Global Positioning System, North-East India, rainfall, crustal movement.

Introduction

The geological setting of the North-East India is very complex. North-East India and its adjoining region display tectonically distinct geological domains occurring in intimate spatial association. Rocks representing the entire geological span i.e. from Archaean to the Recent occur in this very small region. The Brahmaputra Valley is built by the deposition of more than 1000 m thick alluvium upon sag formed during the period of the rise of the Himalaya. This Valley is a relatively narrow valley bounded by two mobile young mountain belts, Mishmi block to the northeast and Meghalaya Plateau to the south (Chowdhury, 2005). The Main Boundary Fault (MBF) and the Main Central Thrust (MCT) are the two major structural element of the Eastern Himalaya which extends upto the strategic southward bend of the Himalaya at Namche Barwa. The MBF has developed during the Pliocene and represents the main central boundary between the Indian lithospheric plate and the Eurasian Plate. The North-East Region lies at the junction of Himalayan Arc to the North and Myanmar Arc to the East. The collision of Indian-Australian Plate and Eurasian Plate involves the large scale of active continental deformation and therefore a rather diffuse seismicity prevails in this region (Chowdhury, 2005).

Climate in India and its North-Eastern region

Koppen, has divided the Indian climate into six major climatic subtypes. The world's highest and massive Himalayan mountain system regulates both the South-West and

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North-East monsoon climate of India. India is home to an extraordinary variety of climatic region ranging from tropical in the South to temperate and Alpine in the Himalayan North, the desert in the West to the heaviest rainfall region in the East. The Cherrapunji-Maushingram area, in North-East India records world's heaviest rainfall regions.

Monsoon in India gives enormous amount of rainfall from June to September every year. India is also the land of world's heaviest rainfall. Scientists who are recently engaged in correlating rainfall and plate movement on Indian tectonic plate have discovered that the speed of the plate gain movement by about 20 percent due to rainfall (Iaffaldano *et al.,* 2011). As the whole North-East India receives more than 300 cm of rainfall annually, it is to be studied whether the plate margin in North-East India is acquiring faster velocity compared to the whole Indian plate due to heavy rainfall or in vice versa whether rain act as an agent to strengthen the velocity of crustal plate.

Methodology and data processing

To understand the crustal movement of North-East India, the research work has been carried out on the latest technology using Global Positioning System (GPS). GPS is the worldwide positioning and time determination system. The total constellation of GPS is 21 satellites with 3 operational spares, unequally spaced in 6 different orbital planes at 20,200 km.

In this research, twelve (12) points in different locations of North-East India have been selected for campaign study. The first field study was initiated in October, 2006 and thereafter it was continued for four years up to

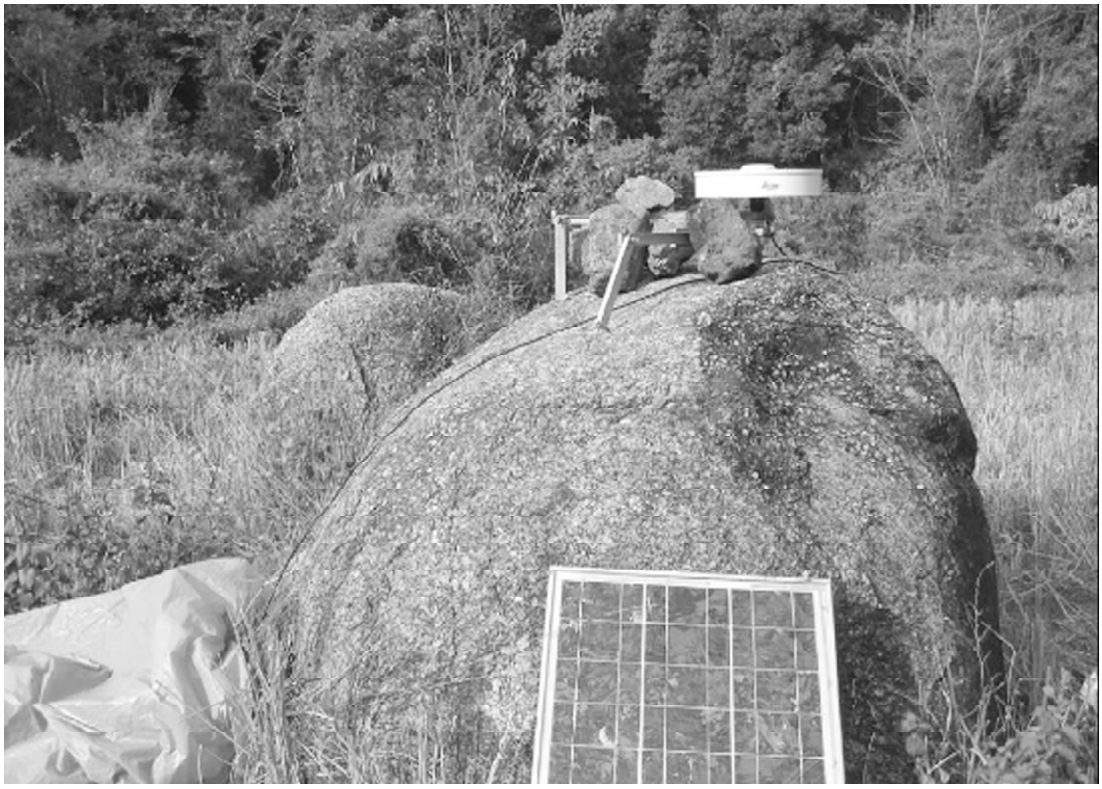

Fig.1: Installation of GPS machine in Natun Bazar, Vill.: Iwathymma, Meghalaya

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February, 2011. These GPS campaign stations are studied with Trimble 5700, Leica1200 and Topcon receivers with choke ring and Zephyr geodetic antennae. The selection of twelve sites were based on hard and stable granite rocks. All the points were selected in an open area without having any disturbance to the antenna. The machines were installed in each campaign sites at least for continuous 72 hours. The machines were set to record its exact location and time in every 30 seconds. The GPS data so collected has been converted into RINEX observation files and quality check has been conducted using TEQC (Translations, Editing and Quality Checking) software. All these processes of quality check plots were carefully examined and data with high cycle slips, multi-path were removed from the analysis (Sunil and Kumar, 2011). The collected data were processed along with the selected permanent stations like Tezpur (TZPR) and Bomdila (BOMP) and IGS (International GPS Service) stations KUNM, LHAZ, HYDE, IISC, POL2, and KIT3. In the processing, we have used GAMIT/ GLOBK software developed by Massachusetts Institute of Technology (MIT), USA. Ambiguity free and ambiguity fixed solutions were performed with ionosphere free linear combination to account for carrier phase ambiguities and signal delay due to ionosphere (Sunil, 2009).

Results

Velocities of all campaign sites were obtained in the ITRF (International Terrestrial Reference Frame) 2005 reference frame from four epochs (four year data) GPS campaign data. The velocity shows that all the sites in

Table 1 Estimation of average velocity of campaign and permanent sites of North-East India

Sl.No.	Name of the Stations	Code	Plate	East (mm/yr)	North (mm/yr)
1	Natun Bazar	NATU	North-East India	42.42	29.53
2	Umrangsho	UMRA	North-East India	38.10	27.51
3	Sokra Pam	SOKR	North-East India	42.04	23.88
4	Panimura	PANI	North-East India	38.39	29.43
5	Raja Gaon	RAJA	North-East India	38.93	28.97
6	Kheroni	KHER	North-East India	40.86	28.44
7	Kumoi	KUMO	North-East India	41.72	27.21
8	Jagiroad	JAGI	North-East India	40.37	28.73
9	Bura Mayong	BURA	North-East India	38.92	28.88
10	Amsoi	AMSO	North-East India	39.73	29.27
11	Kampur	KAMP	North-East India	40.06	29.74
12	Khetri	KHET	North-East India	41.19	29.18
13	Tezpur	TZPR	North-East India	40.77	27.31
14	Bomdila	BOMP	North-East India	43.12	19.79
			Average	40.47	27.70

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Table 2 Estimation of average velocity of IGS sites of Indian and Eurasian plates

Sl.No.	Name of the Stations	Code	Plate	East (mm/yr)	North (mm/yr)
1	Bishkek	POL2	Eurasian	26.64	4.64
2	Kitab	KIT3	Eurasian	28.10	5.75
			Average	27.37	5.19
3	Hyderabad	HYDE	Indian-Australian	39.82	34.06
4	Bangalore	IISC	Indian-Australian	41.27	36.07
			Average	40.54	35.06

Table 3 Summary Table

	East (mm/yr)	North (mm/yr)
Average velocity of Eurasian Plate	27.37	5.19
Average velocity of Indian-Australian Plate	40.54	35.06
Average velocity of North-East India Plate	40.47	27.70

North-East India are moving at an average velocity of about 40.47 mm/year East and 27.70 mm/year North or about 51.37 mm/year towards North-East direction. The average velocity of Indian plate is 40.54 mm/year East and 35.06 mm/year North or about 53.6 mm/year. This is almost similar to the resultant velocity of the Indian plate 53.9 mm/year with respect to ITRF 97 (Jade, 2004). The average velocity of Eurasian plate is 27.37 mm/year East and 5.19 mm/year North or 27.85 mm/year in the North-East.

The above finding clearly shows that the Eurasian plate is more stable than the Indian-Australian plate. The Indian-Australian plate is moving towards North-East with a faster rate. The Northern velocity of Indian-Australian plate is 35.06 mm/year and the North-East India is 27.70 mm/year which means convergence took place in the North-East India with a rate of about 7.36 mm/year. But the Eastern velocity of Indian-Australian plate is 40.54 mm/year and North-East India is 40.47 mm/year i.e. the velocities are nearly same. The crux of the matter is, if the heavy rainfall in North-East India accelerated the movement of the plate towards east (as the massive Himalaya is in the North), then the additional velocity must have been accommodated somewhere else.

Discussion

The North-East Indian region, with its complex geographical setting receives heavy rainfall. Scientists have stated time and again from a thorough research that due to this heavy rainfall in the North-East region particularly in the monsoon, plate movement of this region should be higher. However from a thorough research for the last four years and from the analysed data (Table 3: Summary Table), we are of the opinion that no accelerating velocity is seen in case of the North-East region as compared to Indian-Australian plate. This study clearly shows that the average velocity of the North-East India is slower than the Indian-Australian plate. The East components of velocity of

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both the regions are almost same. Thus the findings arrived at by the scientists after their critical study may not be correct. Hence the larger issue that remains open ended before us is that if for a moment we consider the results arrived at by the scientists are correct then the additional velocity must be equipped somewhere else. The resultant vector of the Indian plate with respect to Sunda plate (in the South-East of the Indian Plate) is 36-38 mm/year out of which about 18-20 mm/year is accommodated across Sagaign fault in the East. A motion of about 20 mm/year gets absorbed in the Indo-Myanmar region (Kumar *et al.,* 2011). If it happens, is there any possibility to accommodate the velocity of North-East India in Sagaign fault or in Indo-Myanmar region?

For the complex geodynamic and geophysical characters, the North-East region demands a serious investigation. We hope to study the region to the extent up to which climate of this region is responsible for triggering plate movement.

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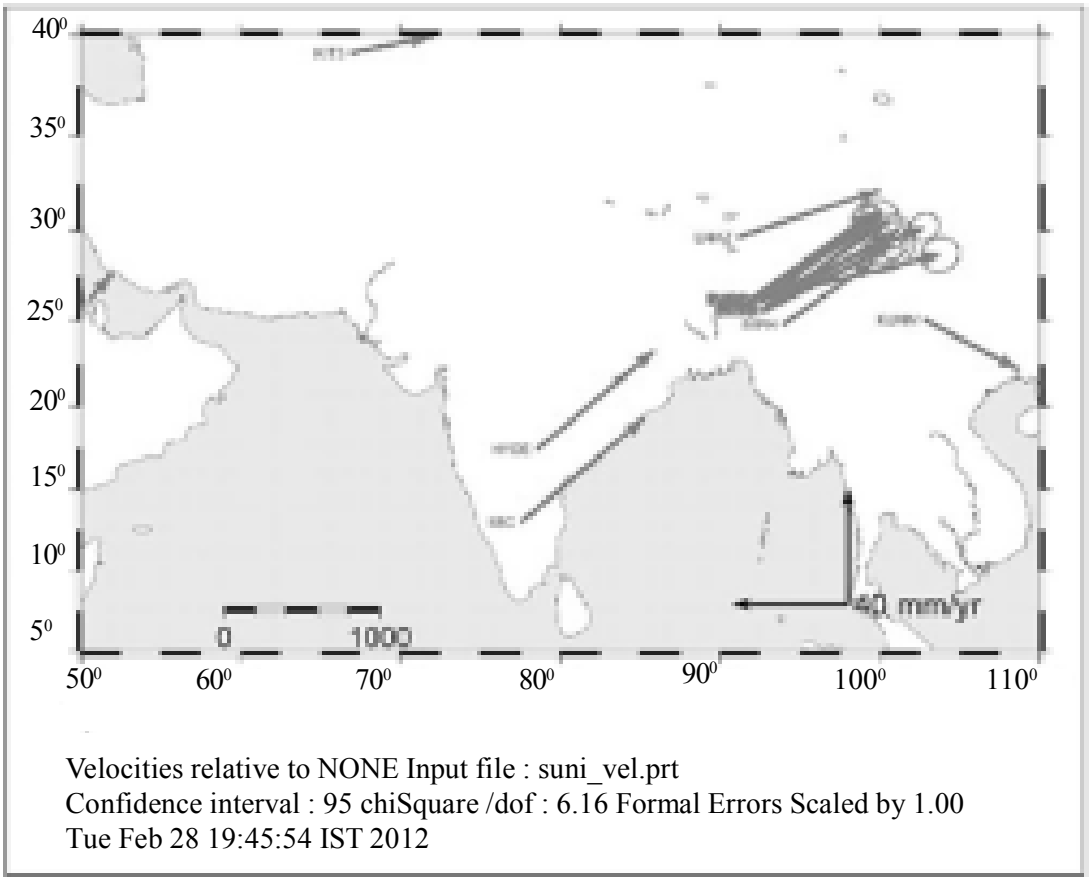

Fig. 2: Velocity plot of various campaign/permanent sites along with IGS stations

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