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Structural Formation & Seismicity of Kopili Fault Region in North-East India and Estimation of Its Crustal Velocity

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Abstract: *In the North-East India region, Meghalaya plateau plays a distinct physical characteristic for its high rising granitic rocks and rocks of Gondwana character. The exposed portion of the Indian peninsular shield is evident in Meghalaya plateau and Mikir hills. Here in the plateau we mainly get Archaean gneissic complex, overlain by proterozoic intracratonic sediments of Shillong group. Upper Cretaceous and Carbonatite ultramafic complex are also evident in Kopili Fault region. The Kopili Fault, which extends from western part of Manipur up to the tri-junction of Bhutan, Arunachal Pradesh and Assam, covers a distance of about 400 km. The Kopili fault bisects the Meghalaya Plateau and isolated the Mishmi block from the main part of the plateau. The fault behaviour is studied using Global Positioning System (GPS) techniques to understand the velocity of twelve (12) different points selected on both bank of the Kopili river, since the fault is almost passing through the river. From a field study of four long years, it is observed that the Kopili Fault region is moving in North-East direction at an average velocity of 28.397N(±1.167) mm/yr and 40.227E(±1.184) mm/yr. This paper makes an attempt to understand the physical development or geological character of the region and its crustal velocity studied on various parts of the Kopili Fault area.*

Key words*: Kopili fault region, global positioning system, Meghalaya plateau, crustal velocity*

I. INTRODUCTION

Studying the seismotectonic morphology of India, it evident that most of the high intensity seismic events occurred in North-Eastern part of India. North East India is one of the five most active seismic zones of the world. It lies between northern collision and eastern subduction margins of the Indian plate. Out of 5 great earthquakes experienced by India of magnitude greater than 8 in Richter Scale (R.S.), 2 occurred in this region. These are the 1897 Great Assam Earthquake and 1950 Assam Earthquake. Besides these, there are 7 events of large earthquakes of magnitude greater than 7 in R.S. occurred in this region till today. Two of them occurred in the Kopili Fault Zone making it seismically unstable. Moreover, there are hundreds of earthquake events occurring in this region signifying the tectonic importance of the fault zone (Das Chowdhury, J. 2005). These earthquakes give a clear picture of the instability of this region. Kopili Fault, which almost bisected the eastern part of massive Meghalaya plateau, also plays a dominant role in triggering earthquakes in this region.

II. THE KOPILI FAULT REGION

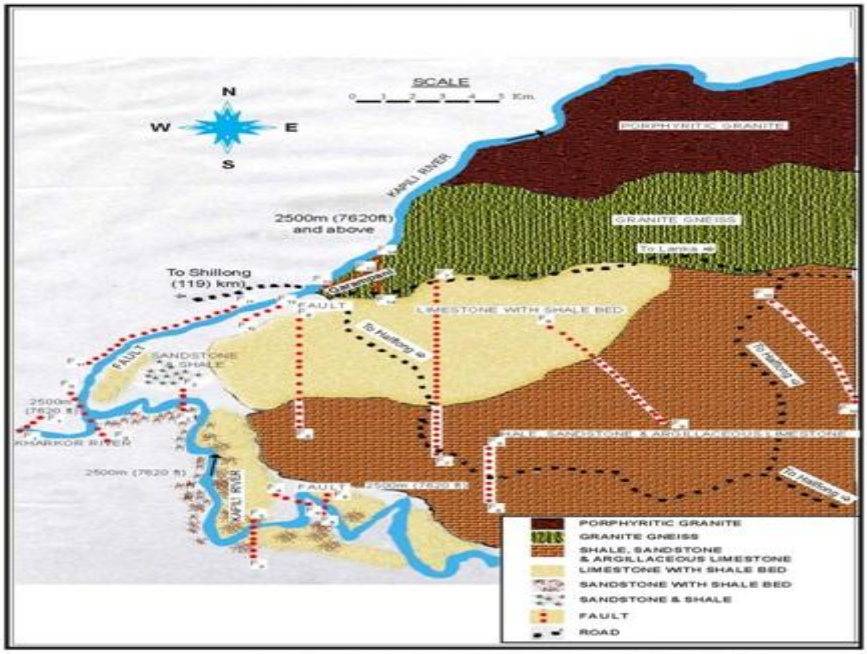
From the starting point, the Kopili River passes over various types of rocks, sands, granites in the hilly region, till it comes out into the plain. To the joining of the Kharkov River, it passes through sandstone with shale bed and argillaceous limestone. Then till Grampian, it passes through limestone with shale bed. From Grampian to Penumbra it passes through Granite gneiss and then through the porphyritic granite.

The river Kopili rises in the North Cachar Hills District in Borail Range at an altitude of 1525 meter. Then it passes through Kopili Ghat, Penumbra, Kheroni, Rajagoan, Kampur, Amsoi, Kumoi, Mayang. The river covers a vast area of North Cachar Hill, Karbi Anglong, Nagaon, and Morigaon District. It is the largest tributary of Brahmaputra on its south bank in Assam. Total length of the river from its source up to its outfall to the Kolong at Hatimukh, a spill channel of Brahmaputra, is 290 km. Total catchment area of the river up to the outfall is 16,420 sq.km. The river flows almost due north in the first 120 km through deep gorges passing over numerous rapids falls till it comes out into the plain of Nagaon district.

Along the course of the Kopili river, there are innumerable cataracts and rapids. The notable among them are the 18 meter fall (almost vertical) located nearly 200 m downstream of the Kopili - Kharkor confluence. Another major cascade with a total drop of 36 meter is visible near the downstream of the Khandong dam site across Kopili. In Panimura area also, one 12 meter notable rapid is visible.

There are many faults in the upper Kopili river region. The developments of the faults have been generally along NE-SW, NW-SE and N-S. In between the Kopili Kharkor confluence and the Garampani, two parallel faults (F_{11}-F_{11}, F_{12}-F_{12}) have been recognized. These are normal faults trending nearly NE-SW and the Kopili river is flowing on the down throw block of these two faults. The famous Garampani hot spring is located near these two faults. One km upstream of the Garampani, there is a NW-SE trending fault (F_0-F_0) which is 18 meter long in the North-South direction crossing the confluence of the Kopili Kharkor. It gives rise to famous Yale Falls. At the upstream of the Kopili Kharkor confluences, five other normal faults (F_1-F_1 to F_5-F_5) trending NE-SW, N-S, NW-SE and traversing along the banks and also cutting these two rivers are recognised. Apart from these, there are many other faults recognized on the bank of the river Kopili. In Kopili Ghat (Sokra Pam) area, there are two small faults, one is N-S and other is NE-SW direction. From the right bank of the Kopili river to the East of the Halflong road there are another five big faults (F_6-F_6 to F_{10}-F_{10}), out of which three are trending N-S, and two are NW-SE direction (Figure 1).

Figure 1: Geological map of upper Kopili Fault region



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III. SEISMICITY IN KOPILI FAULT REGION

The Kopili Fault which extends from western part of Manipur upto the tri-junction of Bhutan, Arunachal Pradesh and Assam covers a distance of about 400km. The topography of the region is such that there is slope from SW to North and almost the whole of its higher altitude region is made up of granite and gneiss. Moreover, the Kopili fault bisects the Meghalaya Plateau and isolated the Mishmi block from the main part of the plateau.

If we analyze the history of major earthquakes in N-E India and its neighborhood we see that out of these, two major Earthquakes of magnitude more than 7 in (R.S.) were occurred in the Kopili Fault Zone. In 1869, January 10, the earthquake with magnitude 7.8 in R.S. occurred at a depth of 60 km along the Kopili Fault zone. This Earthquake has severely damaged the entire Nagaland region. In 1943, October 23, there was an earthquake with epicenter at 27.5° N 93.5° E originated along the Kopili Fault with magnitude 7.3 in R.S. It shook the whole North-East and damaged a lot. During the last 140 years, the Kopili fault has experienced 2 earthquakes of magnitude greater than 7 in R.S., three of magnitude 6 to 7 in R.S. and several of magnitude 4.5 to 6 in R.S (Das Chowdhury, J. 2002).

IV. METHODOLOGY

In this research, total number of twelve (12) campaign points in different locations of North-East India has been selected for campaign study. The first field study was initiated in October, 2006 and thereafter it was continued for four years up to February, 2011. These GPS campaign stations are studied with Trimble 5700 and Leica1200 receivers with choke ring and Zephyr geodetic antennae. The selection of twelve sites was 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. The error free data are analysed using GAMIT/GLOBK software developed by Massachusetts Institute of Technology (MIT), USA. In the processing the reference IGS (International GPS Service) stations KUNM, HYDE, IISC, POL2, and KIT3 are used.

V. RESULTS

After analysis of the data, we finally found out the East component and the North component of velocity plots in millimetre with error estimation. From the table 1, it is observed that the Kopili Fault region is moving in North-East direction at an average velocity of 28.39N (±1.167) mm/yr and 40.22E (±1.184) mm/yr (Table 1, figure 4). It is also observed that the North velocity component is more stable and all points are almost same except Sokra Pam (SOKR). But the East velocity is quite different. Umrangsho (UMRA), Panimuraa (PANI), Raja Gaon (RAJA) & Bura Mayang (BURA) shows less movement whereas Natun Bazar (NATU), Sokra Pam (SOKR) & Kumoi (KUMO) shows more movement. All points are moving almost parallel, except the point Sokra Pam (SOKR), Panimura (PANI) & Kumoi (KUMO) indicates something is happening in those points which force them to move in different way (figure 4). This may also take place due to the presence of local faults near those points or due to the different structural formation of the region.

Figure 2: East Component in mm

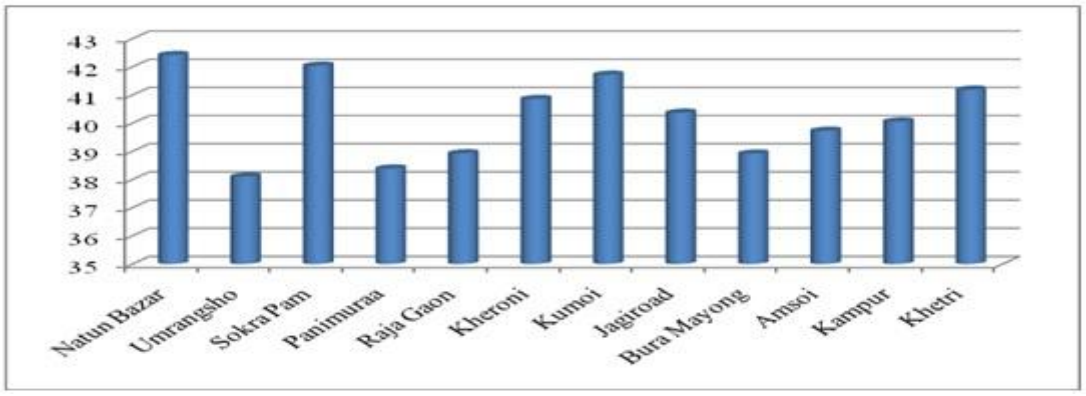
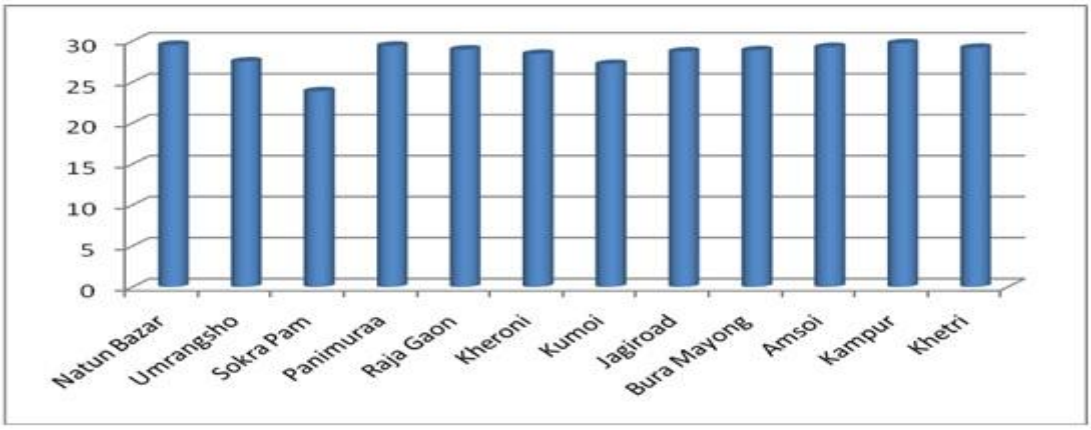


Table I: Estimated velocities of campaign sites of Kopili Fault region (using GLOBK Version 5.19)

Sl .N	*Name of the Stations*	*Station Code*	*Longitude (deg) (Final epoch)*	*Latitude (deg) (Final epoch)*	*Crustal Velocity*	
					East (mm/yr)	*North (mm/yr)*
1	Natun Bazar	NATU	92.85725	25.81246	42.42(±1.06)	29.53(±1.06)
2	Umrangsho	UMRA	92.72512	25.52585	38.10(±.73)	27.51(±.77)
3	Sokra Pam	SOKR	92.73616	25.59636	42.04(±2.44)	23.88(±2.32)
4	Panimura	PANI	92.82508	25.71731	38.39(±.70)	29.43(±.75)
5	Raja Gaon	RAJA	92.62908	26.07280	38.93(±.73)	28.97(±.79)
6	Kheroni	KHER	92.85725	25.81246	40.86(±.67)	28.44(±.73)
7	Kumoi	KUMO	92.24822	26.19624	41.72(±.99)	27.21(±.97)
8	Jagiroad	JAGI	92.20407	26.11709	40.37(±1.04)	28.73(±1.03)
9	Bura Mayong	BURA	92.01294	26.24631	38.92(±1.30)	28.88(±1.25)
1	Amsoi	AMSO	92.48437	26.15559	39.73(±2.25)	29.27(±2.12)
1	Kampur	KAMP	92.64987	26.16261	40.06(±1.31)	29.74(±1.24)
1	Khetri	KHET	92.08036	26.12592	41.19(±.99)	29.18(±.98)
Average Velocity					**40.22(±1.184)**	**28.39(±1.167)**

Figure 3: North Component in mm



VI. DISCUSSION AND CONCLUSION

Observing the continuous seismic activity in the Kopili Fault region, we undertook the Global Positioning System (GPS) study of that region covering the physically assumed Kopili Fault. The most scientific GPS study and its critical analysis reveal a number of unknown facts about the crustal behaviour of the selected points stretching along the bank of Kopili River.

As shown in the table above (Table 1), Natun Bazar (NATU) in Meghalaya and Sokra Pam (SOKR) in Karbi Anglong district of Assam, on the north bank of Kopili river shows highest eastward movement of 42.42 (±1.06) mm/yr and 42.04 (±2.44) mm/yr followed by Khetri (KHET) 41.72 (±0.99) mm/yr and Kumoi 41.72(±0.99) mm/yr. The result based on GAMIT/GLOBK software analysis is at par with all India velocity movement of the

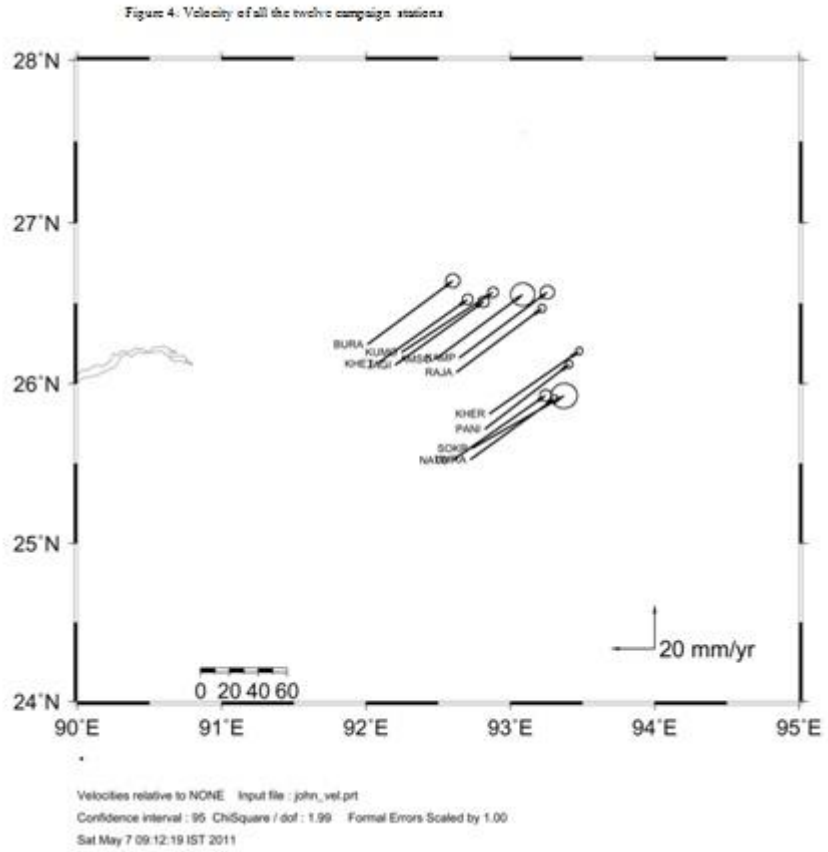


Figure 4: Velocity of all the twelve campaign stations

Indian landmass of its average velocity of 35.28N (±0.47) mm/yr and 41.125E (±0.48) mm per/yr (*Mahanta at. el., 2012*). the difference in various points of the Kopili Fault region, where occurs over 3000 mm rainfall per year is an area of extreme erosion, deposition and tectonic elevation and depression. The Kopili Fault region passes through numerous types of rocks, from new sedimentary to oldest igneous and metamorphic. The fault passes through sands and granites in the high rising areas. In some places sandstone and shale bed and argillaceous limestone formation is also evident. The granite base in the hilly region is mainly of poor pyritic granite and sedimentary layers in the Brahmaputra river valley region which extends towards the north bank of river Brahmaputra bisecting the river near Mayang in Morigaon district of Assam upto the middle Himalayan mountain. After thorough study, the paper comes to the conclusion that the North East region, more specially the Kopili Fault area is a geologically unstable region, surrounded by faults and lineaments and seduction zones in the east. The complex geo-tectonic character of the region compounded with complex geologic formation of old and new rocks play its distinct role in plate movement of the region. As no specific cause may be pin pointed for generating structural movement, the complexity in geologic formation, variations in topographic layers, severely volatile geo-dynamics and extremely high summer rainfall, all in combination played their distinct role in variations in crustal movement at various points of the Kopili Fault region.

VII. ACKNOWLEDGEMENT

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