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ABSENCE OF PRESENT DAY ACTIVE CRUSTAL DEFORMATION ALONG THE CHITE FAULT IN AIZAWL AREA MIZORAM THROUGH GPS MEASUREMENTS

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ABSTRACT

Earthquakes cannot be prevented from occurring and earthquake prediction with accurate forecasting will still not be possible soon in the foreseeable future. However, techniques like studying the crustal deformation with geodetic applications through GPS can help to generate data towards future earthquake hazard assessment and to study the geodynamics of plate motions, the mechanisms of stress and strain building and piling inside the crust which could be potential for future earthquake occurrences. Results of slow and steady deformation are indicative of a seismic hazard, which also depends largely how the time elapsed since the previous earthquakes. The geological feature of Aizawl fault is deciphered, monitored and constrained with GPS to define the present day crustal deformation across Aizawl and also to understand the role that it plays in the geodynamics of the region.

Keywords: *Earthquakes, Deformation, GPS, Mizoram.*

Introduction

Aizawl, the capital of the state of Mizoram is located in the IBW of the plate boundary region in the Indo Burmese Arc (IBA). Here the geodetic aspects of the state and its neighbouring regions are not well constrained due to limited works carried out in the region. More studies on geodesy and geology together can solve the many issues and questions concern with potential future earthquake hazard assessments. Crustal deformation study through the use of GPS, being a cheap and accurate tool can be one of the most efficient methods. During our study we explore, analyse and define the crustal deformation of Aizawl fault for better understanding of the geodynamics of the region.

The Arakan Yoma, Chin Hills and the Naga Hills make up the Indo Burmese Wedge (IBW) and together with the Myanmar Central Basin and the Shan Plateau they make up the whole of the Indo Burmese Arc (IBA). (Fitch 1972; Le Dain *et al.*, 1984). The study region is a part of the IBW and it is defined by an arcuate shape of thick sedimentary basin which consist mostly of arenaceous and argillaceous rocks. The structures and kinematics of the IBW is such that the western margin of the Burma plate is a sliver between the India and Sunda plates. On the western front of the Burma plate, the IBW displays a different grade of metamorphism (Maurin & Rangin 2009).

Numerous earthquakes are frequently occurring in the IBA and along the Sagaing fault regions in the east due to the motion of the India-Sunda plates. This is an area of diffused plate boundaries. Also, two great earthquakes had occurred in the region i.e. the 1897 Shillong Plateau and the 1950 Assam earthquakes. The IBA has now been defined as an accretionary wedge and earthquakes here occur in the depth ranges of 30-60km. GPS results from the region suggest that the northern motion of 35mm/yr between the Indian and the Sunda plate motion is defined by 16mm/yr motion accommodating at the IBA region and the rest of 20mm/yr is accommodated along the Sagaing fault region (Kundu & Gahalaut 2013).

Materials and Methodology

The Global Positioning System (GPS) is designed by US Department of Defense and is officially known as the Navigation Satellite Timing and Ranging (NAVSTAR). It has become a geodetic tool for studying a wide range of geophysical phenomena. In the most widely accepted theory there is active convergence of India beneath the Eurasian plate and subduction of Indian plate in the east across the IBA. We have used the GPS measurements obtained from our GPS campaign data to estimate the rate of deformation across Chite valley in Aizawl city to know the rate of crustal deformation across it. **Fig. 1** shows the study area falls in the NWW-SEE in Aizawl.

To quantify the crustal deformation, we installed a campaign GPS mode network in 2012 within Aizawl city with the establishment of 6 survey mode sites along the presumed Chite fault. The sites selected were at Beraw Tlang, Durtlang, Kendra Vidyalaya Thuampui which all are situated on the eastern flank of the Chite Valley while Saikhamakawn, Armed Veng and Ramthar are situated on the western flank of the Chite Valley. The sites are designated as BERA, DURT, KEND, SAIK, RAMT and ARME and are all located at an elevation of 888.36m, 1214.901m, 923.803m, 937.378m, 888.127m and 767.378m respectively above the mean sea level. All the sites are within 1-2 kms apart from each other. Unforunately ARME site got damaged/vandalised in 2014 and no new site was further established. This campaign mode transects the Chite valley and this network of close distribution of GPS sites help us in the capturing of precise geodetic signal and better enhancement of the noise ratio.

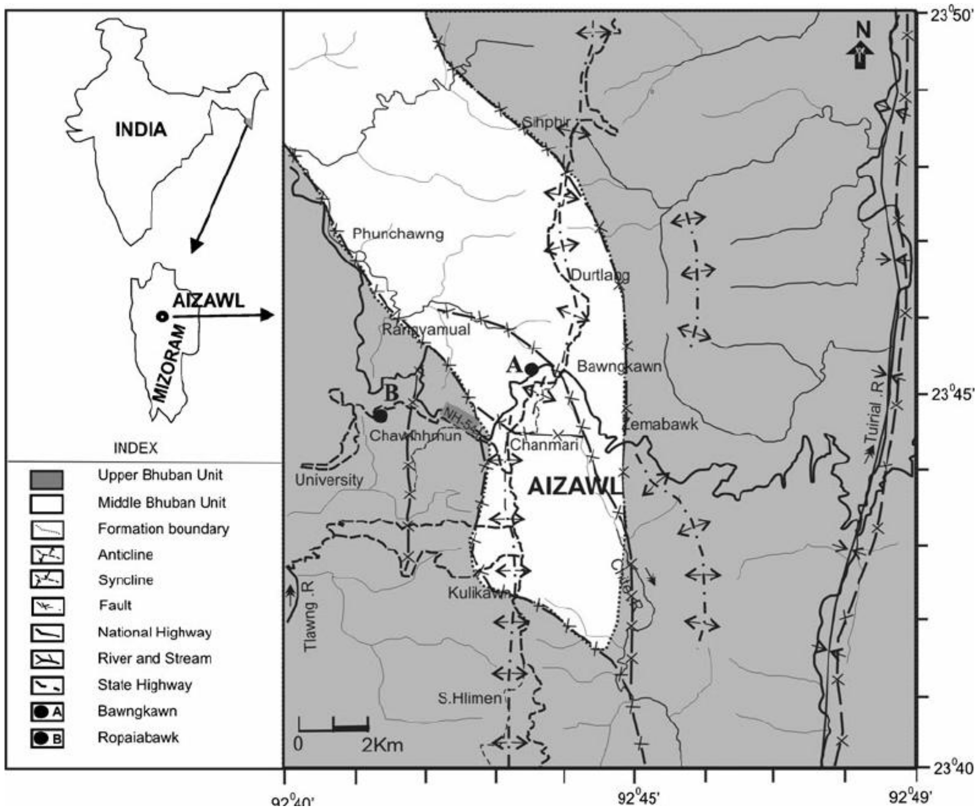

Fig. 1: Location map of the study area

All the sites selected are far from roads, transmission towers and high voltage power lines. We choose sites which area open areas and are far from trees. Normally, we dug an open pit upto 3 feet and bury a steel plate for mounting the GPS antenna. This steel is extended downwards and is cemented and the same site is occupied in the next campaign again. In areas where desirable open areas are not available, i.e. where bedrock or in-situ rocks are not available or exposed, we improvise a bit. In such cases, columns/pillars at the top of the highest rise of buildings are used for placing the GPS sets. These columns/pillars extended below upto 8-9 feet below the surface and rooftops of buildings provide great view for satellite signal transmission and receiver. Since the motion of the GPS sites are considered to be the motion of the upper crust, all these considerations were executed for reliable estimates of motion at the GPS sites.

In the GPS site setup, the mark on the antenna is always kept in the direction of magnetic north. The choke ring antenna reduces the strength of the multipath signals or signals striking at lower angle. *Leica* receivers were used to receive the satellite signals and to store the data. Batteries of 100Ah each were used at all the sites, and the antenna has been attached to receiver with antenna cable. A poly-phaser has been used between the antenna and receiver to avoid its damage due to lightning. The stored raw data was converted into Receiver Independent Exchange (RINEX)/observati-

Fig. 2: Field GPS setup on a top of building and on ground

-on files and later it was used for processing. **Fig. 2** describes a detailed field GPS setup on a top of a building and on ground.

GPS Data Processing

A duration of 3-4 days is used for occupying a single site. Observation from 0 hours GMT to 24 hours GMT for a continous observation of 24 hours is always carried out. The sampling interval for data collection is 30 seconds and all the raw data were then transferred to Receiver-Independent Exchange Format (RINEX) format.

The campaign GPS raw data alongwith 17 International GNNS (Global Navigation Satellite System) Service site (IGS) PIMO, KARR, WUHN, BAKO, XMIS, NTUS, KUNM, COCO, LHAZ, URUM, HYDE, IISC, SELE, POL2, DGAR, KIT3 and SEY1 were processed together with Scripps Orbit and Permanent Array Center (SOPAC) files. GAMIT/GLOBK version 10.40 was used to estimate the time series of site coordinates and their respective velocities. The site position estimates and their velocity rates were estimated in ITRF2008 as shown in **Table 1**.

The derived site velocity estimates using GPS measurements in the Chite valley are presented in ITRF2008 as well as India fixed reference frame and time series for each site were established as shown in **Fig. 3**.

The India fixed site motion has been estimated using the Euler pole of rotation proposed by Banerjee *et al.* (2008) Latitude 52.970±0.217°N, Longitude -0.297±3.760°E, Rotation rate 0.499±0.008133° / Myr, and Ader et al., (2012) Latitude 51.4±0.3°N, Longitude -1.34±3.31°E, Rotation rate 0.5029±0.0072°/Myr.

Table 1: Position estimates and velocity estimates of different sites in ITRF2008

Site	Longitude	Latitude	GPS site velocity (mm/yr)								
			ITRF08			Fixed India Plate			Error		
			East	North	Up	East	North	Up	sigE	sigN	sigU
PIMO	121.07773	14.63572	-26.59	6.12	2.76	-73.94	-22.47	2.76	0.44	0.38	1.85
KARR	117.0972	-20.9814	39.53	58.85	-0.67	3.54	29.12	-0.67	0.31	0.26	1.17
WUHN	114.35727	30.53165	42.78	-7.37	4.02	-2.56	-37.79	4.02	1.6	1.51	6.55
BAKO	106.84891	-6.49106	25.25	-7.33	0.14	-17.76	-39.34	0.14	0.64	0.47	2.06
XMIS	105.6885	-10.4499	41.41	55.48	-0.77	-0.6	23.28	-0.77	0.3	0.23	1
NTUS	103.67996	1.3458	29.23	-10.15	0.66	-15.35	-42.66	0.66	1.45	1.1	4.52
KUNM	102.7972	25.02954	15.61	-16.54	23.02	-27.84	-49.15	23.02	42.4	35.7	127
COCO	96.83397	-12.1883	44.63	53.04	-3.56	2.09	19.81	-3.56	0.29	0.23	0.99
BERA	92.76438	23.73139	35.52	28.94	4.23	-5.87	-4.49	4.23	0.82	0.63	3.5
KEND	92.7399	23.74144	36.9	29.99	3.13	-4.48	-3.44	3.13	1.18	1.04	4.89
DURT	92.73378	23.7555	38.6	30.19	-12.2	-2.77	-3.24	-12.2	3.02	2.66	12.1
RAMT	92.72783	23.741	34.81	29.87	15.04	-6.57	-3.56	15.04	2.25	2.15	9.67
SAIK	92.71922	23.69505	32.12	30.07	11.52	-9.27	-3.36	11.52	2.03	1.93	12.2
LHAZ	91.10403	29.65733	46.62	14.88	1.22	7.6	-18.58	1.22	0.23	0.22	0.89
URUM	87.60067	43.80795	31.55	5.97	1.22	0.3	-27.45	1.22	0.24	0.24	0.84
HYDE	78.55087	17.41726	41.23	36.24	0.98	0.77	3.38	0.98	0.27	0.21	0.92
IISC	77.57038	13.02117	42.9	34.1	-2.91	1.2	1.36	-2.91	0.32	0.23	1.1
SELE	77.0169	43.17873	30.81	0.59	210	3.39	-32.04	210	20.5	22.9	75.6
POL2	74.69427	42.67977	26.8	4.14	-1.3	-0.04	-28.17	-1.3	0.2	0.21	0.68
DGAR	72.37024	-7.26968	47.09	32.7	-0.93	1.78	0.72	-0.93	0.34	0.29	1.21
KIT3	66.88545	39.13477	26.72	4.38	-2.67	0.39	-26.46	-2.67	0.68	0.74	2.54
SEY1	55.47941	-4.67372	24.84	10.78	0.17	-20.94	-16.92	0.17	0.44	0.39	2.16

Results and Discussion

We have represented the GPS site velocities in the absolute reference frame ITRF2008 and relative reference frame (i.e. India fixed) using the Euler rotation pole (Banerjee *et al.*, 2008) as shown on **Fig. 4** and **Fig. 5**.

i) Estimated velocity at all the sites are in ITRF 2008. All these sites show velocity in the NE direction between 45 mm/year to 46 mm/year.

ii) When the estimation of motion of the sites were done with India fixed reference frame there appears to be either no change or no sudden change which is expected from a fault accumulating strain. However, the estimated motion across the Chite

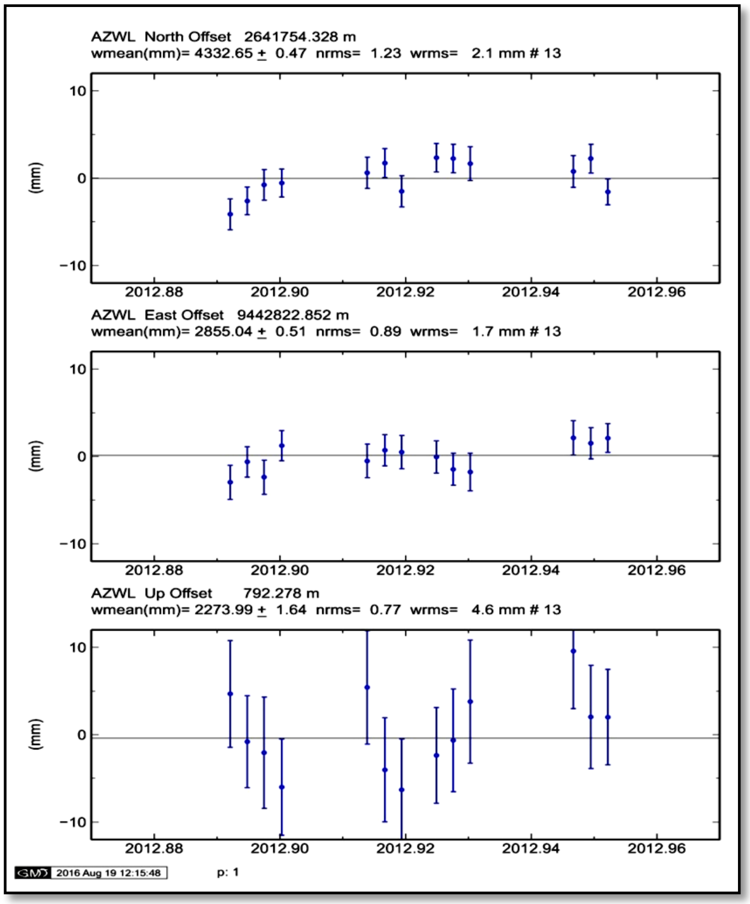

Fig. 3: A single site GPS Times series of Aizawl along the Chite Valley

Valley represent consistent motion corresponding with respect to the fixed India reference frame.

iii) With no geologic, geophysical or geomorphical evidence to support, the absence of any observable velocity difference across Chite Valley clearly indicate either it is an inactive fault or it accommodates very small amount of motion.

In contrast to tectonic deformation, '*superficial*' deformation of the crust where landslides are common and are present in huge quantities. Taking this notion into account and applying this for the study area, the presence of numerous small pockets of landslides and subsidence on either side of the Chite Valley could somehow support superficial deformation. However, we could not conclude on the aforesaid comments since only a four year GPS campaign mode measurements cannot fully resolve the issue. More data and more geological input is needed to resolve this implication.

Concluding Remarks

Based on our study we have found that

a) The crustal deformation of Aizawl obtained from sites along the Chite valley showed that all these sites -

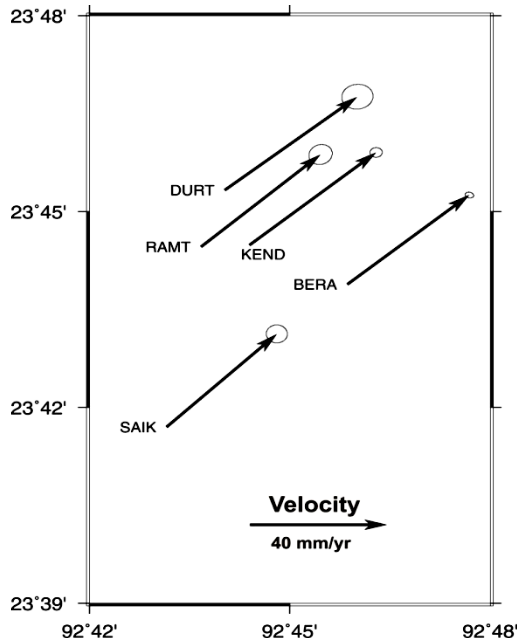

Fig. 4: Horizontal site velocity in Chite Valley, Aizawl in ITRF08 reference frame and the error in the estimate of velocity with an accuracy of (1σ)

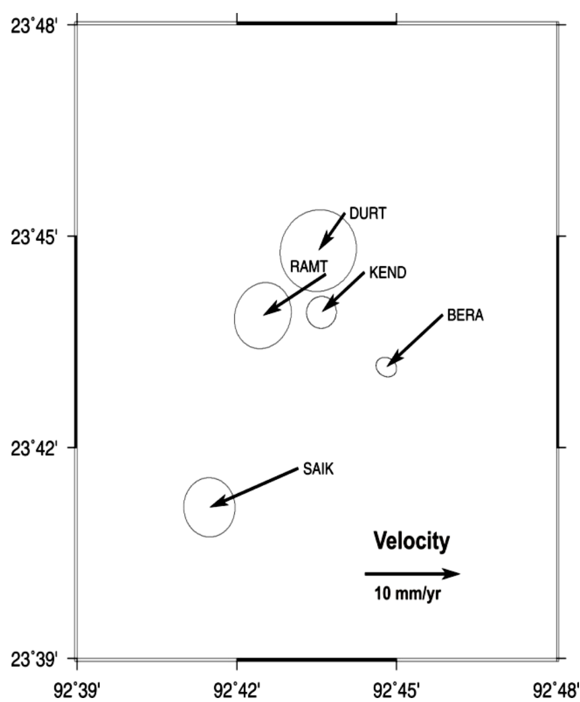

Fig. 5: Horizontal site velocity in India fixed reference frame within Chite Valley, Aizawl and the associated error (1σ) in velocity estimate is shown by ellipse

show velocity in NE direction which is between 45mm/year to 46mm/year

b) To see the effect of motion across proposed Chite fault, we estimated velocity of all these sites in Indian plate reference frame and they signify that they are all moving towards SW direction.

c) There appears to be no sudden change in motion anywhere across the proposed fault.

d) We have found that the proposed Chite fault in Aizawl is not accumulating strain. In fact it might not be a geological fault after all, even it is a fault, it is not active. The geological attributes give more of the resemblance to a geological lineament, and it can be easily mistaken for a geological fault.

e) By looking at the available geological, geomorphological evidences, lack of historic of great and major earthquakes, or even its low seismicity in Mizoram in the past, the proposed Chite fault favour aseismic behaviour.

Since relative plate motion varies depending upon the location of the Euler pole of rotation. This implies that if Aizawl (Chite valley) shows any deformation from the constrained GPS data, there would be difference in the estimates at the different sites. However the motion of sites located on both the eastern and western flanks of the Chite Valley shows that the velocity distribution at all the sites are moving parallel to one another. For this we have represented GPS site velocities in the ITRF2008 frame and relative frame i.e., Indian plate fixed.

The velocities estimates in the ITRF2008 and India fixed reference frame suggest that there is no difference in movement as we compare the movement of the eastern flank of the Chite valley with respect to the western flank of the valley.

Another aspect is the seismic hazard assessment for the state of Mizoram available from our geodetic GPS study is that if there had been gradual increase in velocity, which is indicative that the Chite fault is accumulating strain over the years.

The study was concluded and the findings were that the proposed Chite fault of Aizawl is a linear feature in the landscape and could be mistakenly expressed as a geological fault. Initial expressions and observations could resemble a fault. However the Chite valley represents a lineament comprised of a sort of the surrounding fold aligned hills in an almost straight line i.e. NNW-SSE and could be easily misinterpreted as a geological fault. Also from topographic map and the Survey of India Topo Sheet No 84 A/13 and 14, it appear obvious as a prominent fault, rather it does not behave as such. From the general geological settings identified from the valley such as the river terraces, recent deposits, the drainage patterns and very small identifiable small pockets of landslides on the valley, it is a lineament.

Even if the proposed Chite fault were to be a fault, it is inactive with no resolvable slip on the upper part of the fault which is verified from the GPS data and with the absence of fault scarps, anomalies in the vegetated area, widening of river course and river terraces and other geological and geomorphological features that would support for a geological fault, however their absence ruled out a feauture for a fault.

References

Ader, T., Avouac, J. P., Liu-Zeng, J., Lyon-Caen, H., Bollinger, L., Galetzka, J. & Rajaure, S. (2012). Convergence rate across the Nepal Himalaya and interseismic coupling on the Main Himalayan Thrust: Implications for seismic hazard. *Journal of Geophysical Research: Solid Earth*, 117(B4).

Banerjee, P., Bürgmann, R., Nagarajan, B., & Apel, E. (2008). Intraplate deformation of the Indian subcontinent. *Geophysical Research Letters*, 35(18).

Fitch, T. J. (1972). Plate convergence, transcurrent faults, and internal deformation adjacent to southeast Asia and the western Pacific. *Journal of Geophysical research*, 77(23), 4432-4460.

Kundu, B., & Gahalaut, V. K. (2013). Tectonic geodesy revealing geodynamic complexity of the Indo-Burmese arc region, North East India. *Current Science (Bangalore)*, 104(7), 920-933.

Le Dain, A. Y., Tapponnier, P., & Molnar, P. (1984). Active faulting and tectonics of Burma and surrounding regions. *Journal of Geophysical Research: Solid Earth*, 89(B1), 453-472.

Maurin, T., & Rangin, C. (2009). Structure and kinematics of the Indo-Burmese Wedge: Recent and fast growth of the outer wedge. *Tectonics*, 28(2).