DECIPHERING DIFFERENTIAL UPLIFT IN SHILLONG PLATEAU USING REMOTE SENSING

V. SRINIVASAN
Geological Survey of India, Tripura-Mizoram Division, B.K. Road, Banamalipur, Agartala - 790 001
Email: v_srinivasan_geo@rediffmail.com

Based on digital image processing of Landsat TM digital data covering Shillong plateau, it is proposed that the landmass in the east and west of Shillong plateau could have moved upwards with respect to the middle part. This differential uplift within the plateau could be due to vertical movement along NNE-SSW trending deep-seated faults and granite batholith emplacement.

Introduction

Shillong plateau in Northeast India is bounded to the south by E-W trending Dauki Fault, to the north by Brahmaputra depression, to the west by N-S trending Jamuna Fault and to the east it is covered by Tertiary sediments of Upper Assam (Belt of Schuppen). This plateau is separated from Mikir hills in the northeast by NW-SE trending Kopili Fault system (Das Gupta and Nandy, 1982). The dominant rock types of Shillong massif are Archaean gneissic complex and Proterozoic intracratonic sediments of Shillong Series, intruded by granite batholiths and basic igneous rocks.

Bilham and England (2001) after studying ground-based survey details of Survey of India proposed popping up of Shillong plateau due to vertical upward movement along two reverse faults. The northern reverse fault (named by them as 'Oldham Fault') is stated to be a deep-seated fault extending from 9 to 45 km beneath the surface and so it is not exposed at the surface. This fault strikes ESE and dips at 57° due SSW. They considered the Dauki Fault, which extends E-W along the southern edge of Shillong plateau, as another reverse fault dipping due north. Thus the Shillong plateau, which is bounded by the concealed Oldham Fault in the north and the exposed Dauki Fault in the south, is considered to be popped up.

Digital image processing of Landsat TM data covering Shillong plateau using ERDAS IMAGINE v.8.4 software was carried out to see the surface expression of above bounding faults and other related fractures.

Remote Sensing Study

Principal Component Analysis, which is a digital image processing technique on multiband satellite data, was carried out using ERDAS IMAGINE. Principal Component Analysis No. 2 (Fig. 1a) has brought out the constrictions in the present course of Brahmaputra River and the corresponding high topographic levels in Shillong plateau, while Principal Component Analysis No. 1 (Fig. 1b) has brought out the fracture pattern clearly, as observed below:

(1) There is a distinct correlation between the maximum topographic highs in the Shillong plateau and the constrictions in the present course of Brahmaputra River (Fig. 1a). The eastern part of Shillong plateau has the topographic height above 4000' up to 6441'. Further near Tura in the western part of Shillong plateau, the topographic level again rose above 4000' up to 4628'. To NNE of these highs, the Brahmaputra River shows constrictions at Guwahati (in the east) and Goalpara (in the west). In between these two topographic highs in the east and west of Shillong plateau, there is a broad saddle where the topographic level drops to ~ 1000'. Correspondingly in NNE, there is a broadening in the course of Brahmaputra River.

(2) Fractures trending north to NE are the most dominant fracture system in the Shillong plateau (Fig. 1b). The fracture density is high in the middle part of Shillong plateau and relatively low in the western and eastern parts. Only along some fractures minor displacements could be identified [Example: Chedrang Fault of Oldham (1899) shown as 'C' in Fig. 2].

In the western (UP) part of Shillong plateau (Fig. 2), 70% of fractures have the trend ranging from N-S to NE-SW (Fig. 3A), while in the middle (DN) part, 59% of fractures have the same range in trend (Fig. 3B). In Fig. 2, it is also evident that the fracture density is low in the western (UP) part (west of Chedrang Fault), when compared with the middle (DN) part.

In the eastern (UP) part, annular fracture pattern is evident ('A' in Fig. 2) close to the middle (DN) part. In this 20 km radius area, fracture density is high when compared with other areas of eastern (UP) part (south, west and north of Shillong in Fig. 2).

Interpretation

It is possible that the landmass trending roughly NNE in the eastern and western parts of Shillong plateau could have

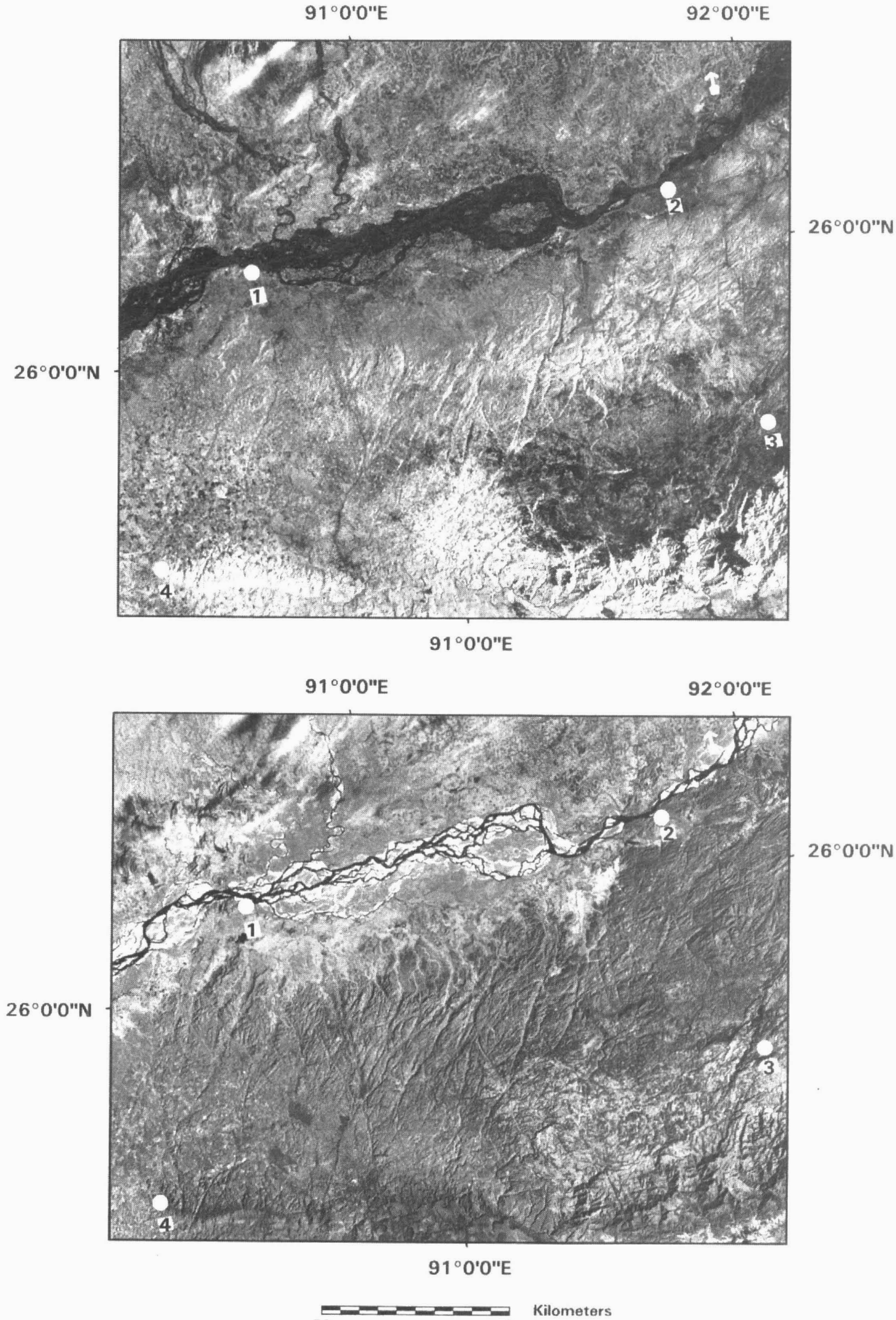

Fig.1. (**a**) Satellite scene depicting the correlation between the topographic highs in Shillong plateau and the constrictions in the present course of Brahmaputra River. (**b**) Fracture pattern in Shillong plateau. Majority of these fractures trend north to NE and the fracture density is high in the middle part of Shillong plateau. 1 - Goalpara, 2 - Guwahati, 3 - Shillong, 4 - Tura.

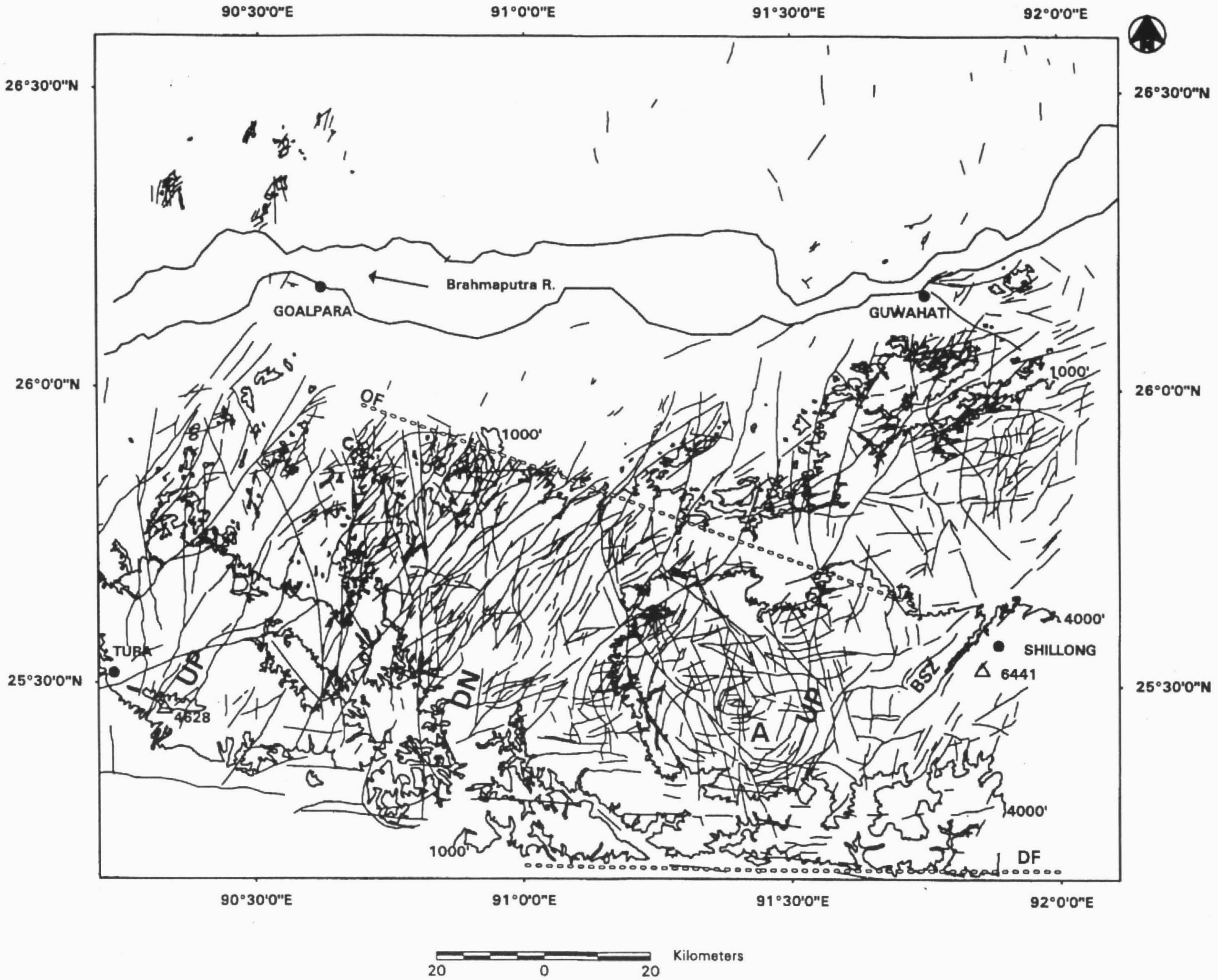

Fig.2. Map depicting fracture pattern in Shillong plateau. 1000' and 4000' contours are drawn to show the correlation between the topographic highs in the east and west of Shillong plateau and the constrictions in the present course of Brahmaputra River at Guwahati (in the east) and Goalpara (in the west). UP - Upward moving landmass, DN - Relatively downward moving landmass, OF - Projection of Oldham fault at the surface level, DF - Dauki Fault, A - Annular fracture pattern, C - Chedrang Fault, BSZ - Barapani-Tyrsad Shear Zone.

moved up with respect to the middle (saddle) part (Fig. 2). This differential uplift seems to have been caused by vertical movement along deep-seated faults that are likely to trend almost perpendicular to the trend of deep-seated Oldham Fault ('OF' in Fig. 2) proposed by Bilham and England (2001). The annular fracture pattern observed in the eastern part ('A' in Fig. 2) may be due to the domal type uplift by the intrusion of granite batholith, such as South Khasi Batholith. In the middle (saddle) part, the density of fracture system is high and this may be due to the rising landmass in the east and west exerting pressure in the middle part.

Discussion

Bilham and England (2001) proposed that the crust in this part could have flexed upwards due to the load of the Himalayas in the north and Bengal fan deposits (thickness of about 23 km) in the south. Then this bent crust was ruptured (the concealed Oldham Fault in the north and the exposed Dauki Fault in the south) and the fault-bounded block (i.e. Shillong plateau) was popped up. Interestingly E-W to ESE-WNW trending longitudinal fracture/ fault system to support this flexuring model is not prominent and only 6 to 7% of fractures fall in this range (Fig. 3). Bilham and England (2001) assumed that the Dauki Fault in the south is a reverse fault dipping towards north to support their pop-up model for Shillong plateau. However field observations at many places indicate this fault to be dipping towards south and so normal in nature (Nag et al. 2001).

Das et al. (1995) using remote sensing data proposed that the alluvial area lying south of Dauki Fault in Bangladesh shows differential upliftment/subsidence due to vertical movement along N-S trending faults. So there could be few N-S to NNE-SSW trending faults in the basement extending from Bangladesh plains in the south through Shillong massif to Brahmaputra plains in the north, causing the landmass in the east and west to move upwards with respect to the middle part.

Conclusion

Based on the remote sensing study it is proposed that there could be a differential uplift in the Shillong plateau and this could be due to vertical movement along the deep-seated NNE trending faults. The eastern and western parts of the plateau could have moved up as NNE-SSW trending landmass with respect to the middle (saddle) part. The doming observed in the eastern part (annular fracture pattern) could be due to emplacement of granite batholith in the upward raising landmass. Remote sensing study does not support the existence of any major fault along the northern edge of Shillong plateau.

Acknowledgements: The figures in this paper were generated

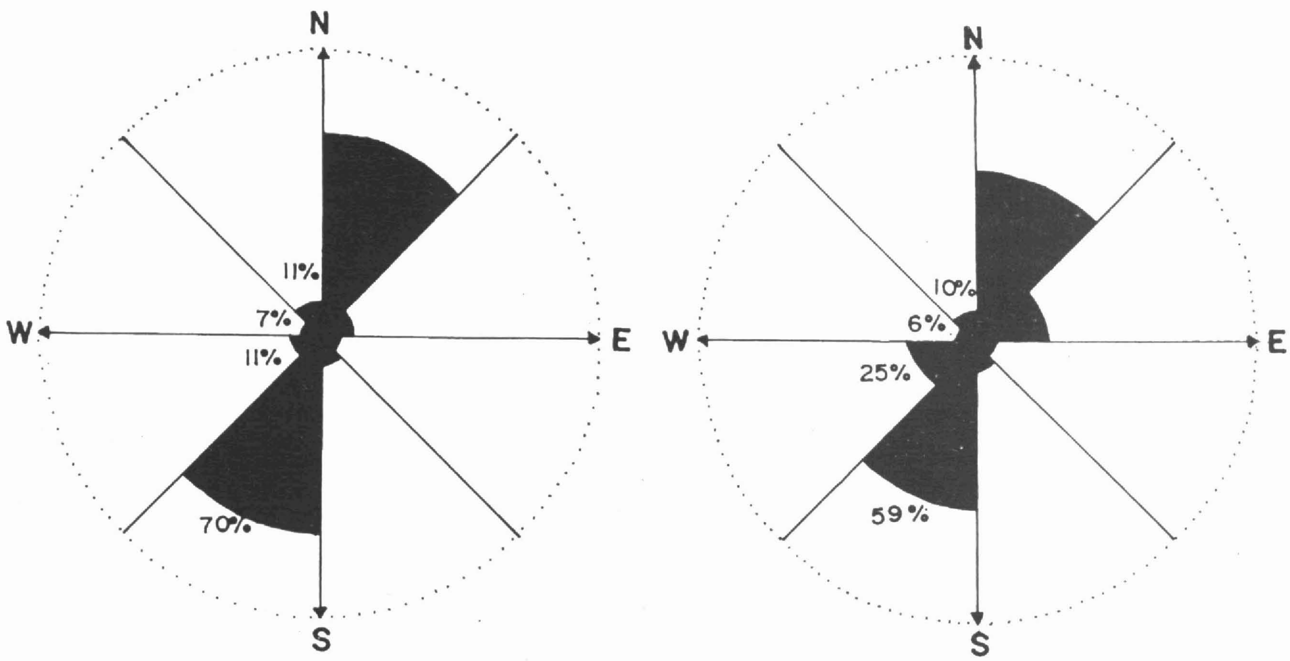

Fig.3. Rose diagram of fracture trend in (**A**) Western (UP) part and (**B**) Middle (DN) part of Fig.2.

using ERDAS IMAGINE software. The author thanks the anonymous reviewers of Journal of Geological Society of India for improving the presentation of this paper and Dr. T. Sesha Rao, M.D., ERDAS INDIA for his encouragement in publishing the research findings.

References

Bilham, Roger and England, Philip (2001) Plateau 'pop-up' in the great 1897 Assam earthquake. Nature, v.410, pp.806-809.

Das Gupta, Sujit and Nandy, D.R. (1982) Seismicity and tectonics of Meghalaya Plateau, Northeastern India: Proc. VII Symp. on Earthquake engineering, University of Roorkee, v.1, pp.19-24.

Das, J.D., Saraf, A.K. and Jain, A.K. (1995) Fault tectonics of the Shillong Plateau and adjoining regions, northeast India using remote sensing data. Int. Jour. Remote Sensing, v.16 (9), pp.1633-1646.

Nag, S., Gaur, R.K. and Tapan Pal (2001) Late Cretaceous-Tertiary Sediments and Associated Faults in Southern Meghalaya Plateau of India *vis-à-vis* South Tibet: Their Interrelationships and Regional Implications. Jour. Geol. Soc. India, v.57, pp.327-338.

Oldham, R.D. (1899) Report on the Great Earthquake of 12 June 1897. Mem. Geol. Surv. India, v.29, pp.1-379.

(Received: 8 April 2002; Revised form accepted: 13 March 2003)