A GIS based tectonic map of northeastern India

Northeastern India (NER) and its adjoining areas are one of the most complex tectonic provinces in the world. Various tectonic features with their complicated geotectonic set-up influence the NER to be seismically very active, as is revealed from smaller-magnitude earthquakes that release sizable energy daily. During the last more than 100 years, the region has experienced 20 large ($M \geq 7.0$) and two great earthquakes ($M \geq 8.5$); the two large earthquakes[1,2] occurred on 12 June 1897 and 15 August 1950. The Eastern Himalayan collision belt to the north consisting of the Main Boundary Thrust (MBT) and Main Central Thrust (MCT); the Indo-Burma subduction zone to the east; the Shillong Plateau, the Mikir Hills and the Assam valley – jawed between the Himalayan arc and Burma arc, form the major tectonic domains of NER[3].

In order to obtain a comprehensive idea about geologic and tectonic settings of NER, it is essential to prepare a tectonic map based on geological field observations. Most parts of NER are highly inaccessible and difficult for geological field survey. The Geological Survey of India (GSI) made the first attempt[4] to produce the regional geology map of the entire NER as well as of the adjoining region with the help of remotely sensed data available via satellite imagery studied in conjunction with available geologic maps of the area covering 88–98°E longitude and 20–31°N latitude during 1965–74. The satellite imageries were generated by NASA, USA and were obtainable through the EROS Data Center, USGS. All morphotectonic lineaments were drawn and their significance evaluated later by comparing the available information on ground truth.

By and large, the tectonic map of NER prepared by Nandy[4] is used for correlation with seismotectonics study. To supplement this map, the tectonic maps of Murthy *et al.*[5], and Kayal and De[6] are also utilized. It has been observed that a few faults and lineaments in the tectonic maps of Murthy *et al.*[5], and Kayal and De[6] do not exist in the tectonic map of Nandy[4] and vice versa. Hence, it was desired to develop a new tectonic map incorporating all the major faults and lineaments that exist in these maps with the help of GIS (Geographical Information System) software package MAPINFO (professional version 5.5). Existing tectonic maps of NER[4–6] are the prime inputs for development of GIS-based tectonic map of NER. The map is delimited by latitude 22°–30°N and longitude 89°–98°E, covering a considerable portion of NER. Recently, the demarcated Brahmaputra fault[7] that separates Shillong plateau from the Himalayas to the north has also been included as an input to this map. The methodology involved scanning the tectonic maps and converting them into computer-readable format. The scanned images form the raster data which are viewed through MAPINFO layer by another layer. After raster, the faults and lineaments present in these maps were digitized separately using MAPINFO. In order to digitize, it is essential to define the position of geographical objects relative to a standard reference grid, which is called geo-coding. Since these tectonic maps are well demarcated by geographical coordinates (latitudes and longitudes), it is easy to geo-code the map. After geo-coding a minimum of four reference points, we obtained accurate information about geographical coordinates of all the ungeocoded parts of the maps. After these processes of geo-coding, any desired fault and lineament in digitized format could be extracted separately into ASCII files. Then all the digitized faults and lineaments were combined into a single layer in MAPINFO and superimposed onto the NER, India geographical map. Thus we obtained the modified tectonic map (Figure 1) of the region. While preparing the GIS-based tectonic map, high-resolution satellite imagery from Indian Space Research Organization recorded by LISS-3

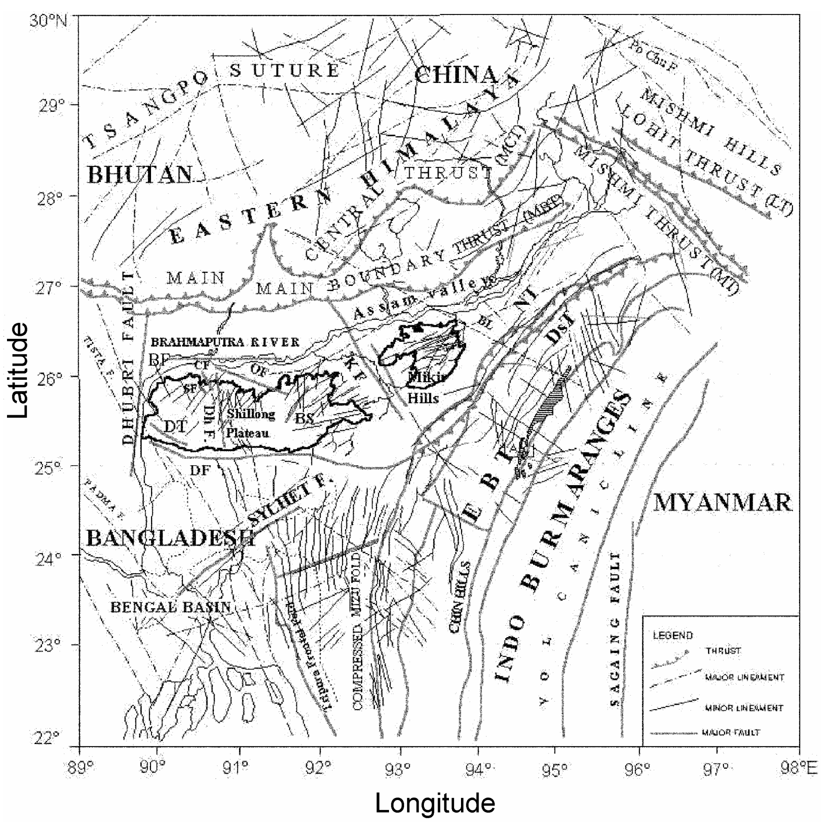

Figure 1. Tectonic setting of northeastern India and the surrounding regions (after Nandy[4], Murthy *et al.*[5] and Kayal and De[6]). The major tectonic features in the region are indicated. MCT, Main Central Thrust; MBT, Main Boundary Thrust; DF, Dauki Fault; DT, Dapsi Thrust; Dh F, Dudhnoi Fault; OF, Oldham Fault; BF, Brahmaputra Fault; CF, Chedrang Fault; SF, Samin Fault; BS, Barapani Shear Zone; KF, Kopili Fault; NT, Naga Thrust; DsT, Disang Thrust; EBT, Eastern Boundary Thrust; BL, Bomdila Lineament; MT, Mishmi Thrust and LT, Lohit Thrust.

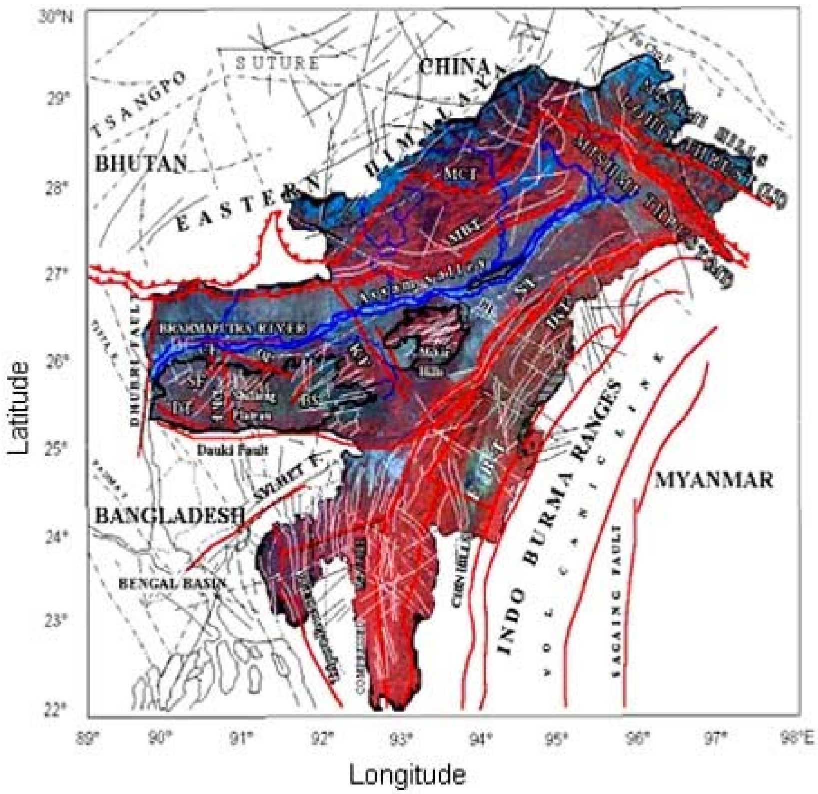

Figure 2. Tectonic map (as in Figure 1) in correlation with LISS-3 imagery (modified after Nandy[4], Murthy *et al.*[5] and Kayal and De[6]).

satellite (resolution 23.5 m) during 2003 was used. The digitized faults and lineaments were loaded over the imagery (Figure 2). Image processing, perception and transformation were carried out. Digitized faults and lineaments that match with the geological features observed in the imagery were considered for the modified tectonic map. We carried out field observations to map the Chedrang Fault (indicated as CF in Figure 1) in the East Garo Hills, Meghalaya with hand-held GPS receiver throughout the Chedrang river course as the fault is aligned with the river. The field observations ended at the confluence of Chedrang river and the Krishnai river starting from the hilly terrain. The geodetic data so obtained from the GPS receiver were additional inputs to the tectonic map of NER. The focal mechanism solution obtained through waveform inversion of an event suggested the thrust faulting with a significant portion of strike-slip motion and the associated fault, i.e. Chedrang fault dips towards north of northeast[8]. Hence the new tectonic map in digital format has been evolved from maps of Nandy[4], Murthy *et al.*[5], and Kayal and De[6], in correlation with satellite imagery.

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