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A.1

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# Seismotectonics Overview of Surma Valley in Northeast India

Saitluanga*

## Abstract

*Surma valley and its adjoining area is one of the most complex tectonic provinces in the world. The geographical boundary with latitude 220-260N and longitude 900-950E covers a considerable portion of NER, India. Plate boundary zone and the intraplate area are the main components of NER, India. The intraplate part of the region comprises the Shillong Plateau, the Mikir Hills and the Assam valley jawed between the Himalayan and Burmese arc, Tripura folded belt, Brahmaputra Valley and the intermountain depression of upper Assam. Besides these, Surma valley is also a complex tectonic feature comprising two active faults namely Mat and Sylhet fault. All these features with its complicated geotectonic setup influence the NER, India to be seismically very active which can be revealed from smaller magnitude earthquakes that release sizable energy daily.*

***Keywords:*** *subduction, zonation map, magnitude, syntaxis zone and Mat fault.*

## Introduction

Northeastern region of India lies at the junction of the Himalayan arc to the north and the Burmese arc to the east. It is seismically one of the six most active

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A.2



# REPORT ON RECENT EARTHQUAKES IN EASTERN PARTS OF MIZORAM

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## INTRODUCTION

The eastern part of Mizoram have been shaken by a number of earthquakes very recently. Some of the tremors were recorded by National Center of Seismology. Apart from the official national website, other agencies also recorded few of the many tremors. But many of these tremors felt by the local people nearby the epicenter were not recorded any institutions or agencies.

Out of the many earthquakes, a magnitude of 5.5 earthquakes which struck the eastern part of Mizoram, India on 22nd June, 2020 at 4:10 AM local time was the largest and was mainly responsible for damage of buildings, fracture on the ground and rock falls along the road. This event is followed by a series of earthquakes felt by locals in the epicentral area, which made them frightened and led them in an extremely terrible situation. Immediately after the main event we visited the epicentral area for field investigations pertaining to intensity assessments.

## General Geology and Tectonics of the area

The Tripura-Mizoram area, a part of Neogene Surma basin, comprises a belt of elongated folds with marked sub-meridian trend and arcuate shape with westward convexity. This fold belt, parallel and subjacent to the Arakan Yoma subduction/ suture zone, is spectacular in the Indian sub-continent and has evolved within a compressive stress field generated by the eastward drift of the Indian plate during late Tertiary.

The Neogene Surma basin of which the present area is a part, is limited by (a) the post Barail unconformity *(close of Oligocene)*, subsequently faulted, to the east, (b) the E-W Dauki fault and the Disang Thrust to the north and (c) the Sylhet fault *(Das Gupta, et al., 1982)* and the Barisal Chandpur high *(Sengupta, 1966)*, concealed below the alluvium of Bangladesh, to the west and northwest.

The entire sedimentary column of the area is constituted of sandstone, siltstone, shale, mudstone, sand rock, silt and rare pockets of shell-limestone, which is divided into four major stratigraphic units based mostly on lithologic characteristics. Sequentially they are, (1) Barail sandstone and shale, (2) Surma Group *(Miocene)* consisting mainly of (a) arenaceous Lower Bhuban Formation (b) argillaceous Middle Bhuban Formation (c) arenaceous Upper Bhuban Formation *(1100 m)* and (d) argillaceous Bokabili Formation *(1000 m)*, overlain by (3) Tipam Group *(Pliocene; + 1300 m)* consisting. of feldspathic sand with fossil wood and minor silt. The youngest (4) Dupi Tila Formation *(not shown in figure 1)* consisting of mottled clay, fine silt and

A.5



# Distribution Of Earthquakes And Their Relations To Major Lineaments In Mizoram and its Vicinity

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***Abstract :*** The most important components pertaining to the seismotectonic study are wide but these primarily and mainly relates to the better estimation of hypocentral parameters. Best estimated hypocentral parameters are the prime input to the Seismotectonic study of any region. The study begins with the prediction of seismicity map which ascertains comparatively high and low seismically active region. A regional seismicity map for Surma valley and the adjoining region, covering the area bounded by longitudes 90° to 95°E and latitude 22°N to 26°N has been prepared by plotting the earthquake data for the period from 1969- 2010 (source: ISC) over the generalized tectonic maps of the region.

## I. INTRODUCTION

Mizoram, a part of Surma valley, lies in a highly seismic zone of NER in which about 10 large earthquakes (M ≥ 7.0) have occurred during the last 100 years.The high seismicity in the region is attributed to the collision tectonics between the Indian plate and the Eurasian plate in the north and subduction tectonics along the Indo-Burma region (IBR) in the east (Dewey and Bird, 1970; Kayal, 1996, 1998; Molnar and Tapponnier, 1975, 1977). In order to have a comprehensive idea of geologic and tectonic settings, it is essential to prepare a tectonic map based on geological field observations. Some parts of the study area are inaccessible and it is difficult to conduct geological field surveys in these places. With the advancement of technology and information available, high quality imageries are available under certain terms and conditions for personal use and research purposes. The high resolution satellite imageries are generated using sophisticated instruments and advanced techniques which make them very reliable and precise and can endure extreme close-up. Earthquakes generally occur within well defined areas of the world, on which there is a striking pattern of continuous belts of activity (Seeber, 1985). Geological, tectonic, geophysical, seismotectonic and G.I.S. studies of the region are studied in order to provide a context for the subsequent analysis and bring out the complexities of the area which are also reflected by the seismicity and kinematics of plate motion of the Surma valley and its surrounding.

## II. METHODOLOGY AND DATA PROCESSING

Present study comprises the re-look into the seismic activity of the region apart from the inferences made through seismicity parameters. Continuous monitoring of earthquakes during the last couple of years in Surma Basin with seismic stations of Agartala, Manipur, Shillong including a Broadband seismograph in Aizawl, the Capital city of Mizoram- has improved the knowledge about the present day seismic activity and seismo tectonics of the region. The seismic activities are studied on the basis of data collected during 1959 to 2009. However most of the events are relocated during the period 1982 to 2009. These data are the hypocenter data file compiled jointly by RRL-Jorhat and NGRI-Hyderabad complemented by phase data from IMD-Shillong, IIG-Shillong, Manipur University, Gauhati University and Mizoram University (Figure 1). A close comparison with EHB location (www.isc.ac.uk/EHB) has been made for some moderate to large earthquakes. For these earthquakes the difference of hypocentral parameters is about 2-3 kms between these two datasets.

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Chapter 34

# Study of Vp/Vs versus Depth Variation within the Seismogenic Zone in Surma Valley along Selected Depths

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**ABSTRACT:** An emphasis has been made to observe the variation of Vp/Vs ratio for shallow earthquakes recorded at close distances within the seismogenic zone in Surma valley along selected depths ranges to identify and to obtain reasonable physical properties of the crust underneath. Simultaneously how the valley is related to its adjoining region, so far as the physical properties among the regions are concerned, becomes useful in identifying gross lateral changes within the region.

## INTRODUCTION

It is well known that compressional and extensional seismic waves in the crust exhibit significant regional variations. P-wave and S-wave travel time propagating from focus with equal time independent of azimuth show different characteristics in various regions. The seismic signal which is recognized as the first arrival depends on the crust – upper mantle structure between source and receiver, instrumental magnification and the noise levels at the recording site. Simple technique involving the earthquake data, including Wadati-Riznichenko diagrams allows one to resolve the tradeoff in origin time and focal depth. Estimates of the average half space velocities for P- and S-waves, and of the travel time ratio (Ts/Tp) helps to understand the material property of the upper crust. A comprehensive variation of velocity of P- and S-wave arrivals with depth can be regarded as the path and site specific inhomogeneities between the source and receiver. The ratio of a P-wave velocity over an S-wave velocity offers important information on the physical properties of the continental crust. The Vp/Vs ratio of crustal rocks are mainly controlled by the mineral contents of plagioclase with high Poisson ratio and silica with low Poisson ratio. The presence of crustal fluids of partial melting form a high Vp/Vs ratio because shear wave velocities diminish more at the presence of fluids within the upper crust than compressional wave velocities hence observation regarding Vp/Vs ratio could help to gain a better understanding about the characteristics of crust and researchers have used Vp/Vs ratio to infer the property of the crust.

## MATERIALS AND METHODS

P- and S-wave arrival time data from shallow and intermediate depth earthquakes recorded by selected seismic stations network in the Northeast during 1982 to 2009 are used for this study. Origin time, epicentral coordinates (latitude and longitude) and depth of the earthquakes were determined using the HYPOCENTER computer program of Linert *et al.* (1986). For initial location of the micro-earthquakes the velocity of upper crust (0–20 km) was assumed to be 5.5 km/s and the lower crust (21–40 km) to be 6.5 km/s and the mantle (below 40 km) to be 8.1 km/s.

The reconstructed travel time of P- and S-waves versus epicentral distances obtained from the best linear fit of Wadati and Riznichenko diagrams are used to determine the ratio of the velocity of Vp/Vs versus depth in Surma valley and its vicinity comprising the upper crust beneath Mat fault area in the eastern part and Sylhet fault area in the northern part. Depth ranges are selected at 20 km intervals and the parameters are distributed accordingly.

In addition, a set of 20 earthquakes are used for determination of Vp and Vs associated to Mat fault region at different depth ranges and 19 earthquakes are used for determination of Vp and Vs in Sylhet fault region at different depth ranges respectively. Certain standards were used to select the earthquakes for this set; firstly, the P and the S phases should be well recorded by at least five stations; secondly, the earthquake should occur within the study area and; finally, the reading of P and S phases should be accurate one.

## RESULTS

The Vp/Vs ratio down to a depth of 60 km from the obtained P- and S-wave travel times is computed. Vp/Vs ratio has been estimated by dividing Vp by Vs using the results obtained from Wadati and Riznichenko diagrams. It uses direct P- and S-waves with predominant frequencies of

B.2



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Chapter 33

# Geotechnical Studies of Bawngkawn Landslide, Aizawl District, Mizoram

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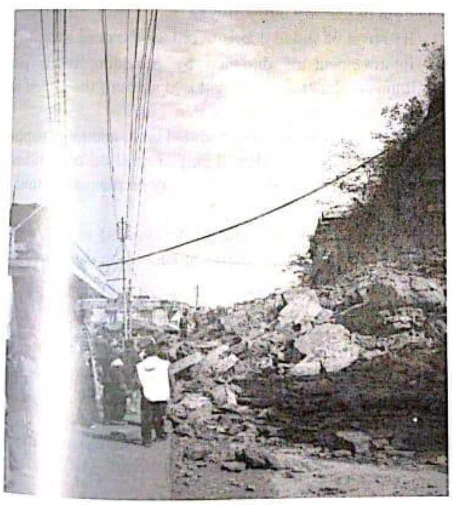
**ABSTRACT:** The Bawngkawn landslide area is 5.5 kms from Aizawl town on the Aizawl-Lunglei road. It covers length – 250 m, height – 150 m and width – 25 m. Sandstones, shales and siltstone-shale alternations are the main components. It is a highly unstable layer, and instability in the area stems from the intersection of three sets of joints dividing the rock beds into blocks of varying dimensions. Rocks excavation and repeated blasting in the past could be major factors. Improvement of drainage, retaining walls along the roadside, and prohibition of further construction are suggested.

***Keywords:*** *Landslide, Bawngkawn, Sandstones, Shales, Siltstone-SHALE, Drainage.*

## INTRODUCTION

The slided area (Lat 23° 45′ 30″ N and Long 92° 44′E) is located at about 5.5 kms from Aizawl town (about 700 m from Bawngkawn police point) on the Aizawl – Lunglei road (NH 54) (Plate 1 and 2). The area belongs to western aspect of the NW-SE trending hill range in Bawngkawn locality and forms a part of the Survey of India Topsheet nos. 84 A/9 and A/10. A road passes through the middle of the hill face and a sidedrain runs from the left flank of the area. The vegetation in the area is scarce.



'late 1: Eastern View of Bawngkawn Landslide

**Plate 2:** Western View of Bawngkawn Landslide

The dimensions of the slides are: length – 250 m, height – 150 m and width – 25 m. The material involved in the sliding is debris and small and large blocks of rocks. The supply of the material is from four to five metres thick overburden and 150 m hill face composed of highly weathered and joined sandstones intercalated with thin layers of shales and siltstone alternation.

### Geology of the Area

The dominant rock types exposed in the area are sandstones, shales and siltstone-shale alternations. These form the sandstone-shale Unit of Middle Bhuban Formation (Tiwari and Kumar, 1995). The sandstones are thickly bedded, grey to brown coloured, medium to coarse grained, relatively

C.1

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# Rockfall Hazard and Risk Assessment along Aizawl-Durtlang Road Section, Mizoram, India

*Raghupratim Rakshit[*] & Bubul Bharali[**]*

## Abstract

*Aizawl is growing in an anticline where Middle Bhuban rocks are found be present along ridge which show high topographic slope on both sides of the axis. The elevation difference, high slope variability, variable rock strength and litho-association are important factors in the stability of the rock beds around the region. The area is susceptible to many landslides and some of them are also subjected to rockfall events. Most common rockfall event have been observed in Aizawl Durtlang road section. In this area vulnerability study has not been done to such an extent and therefore hazard assessment was required to understand the hazardous localities. The area is subjected to rockfall events rather than other sliding mechanisms occurred in other areas. The*

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C.14

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# Morphotectonic Aspects and Their Relationship With Landslide Prone Areas of Sairang River Basin, Aizawl, Mizoram, India

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Richard Lalrinzuala*** Bubul Bharali****

**Abstract**

*Tectonic processes are responsible for the formation of different topographic expressions. During Tertiary, such series of tectonic activities formed the Mizoram Fold Belt region where Aizawl is situated. The study area is gone through adverse effects of landslides, rock fall, slumping and many other natural disasters. This study aims to demarcate not only some visible or active landslides but to understand the role of active tectonics and geological factors in creating vulnerable regions around the Aizawl city. The morphotectonic parameters and lineament analysis techniques able to indicate ancient slide zones and helped us to reveal the controlling factors associated with dynamic movement history and changing slide patterns. Morphotectonic parameters are delineated from data products that are used in the present study are topographic maps, satellite imageries, Digital Elevation Model (DEM), geological data collected from field investigation. Different lineament density*

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# SEDIMENTOLOGICAL APPROACH TO UNDERSTAND EVOLUTION OF MIZORAM FOLD BELT

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## ABSTRACT

Mizoram fold belt comprises of the Tertiary sediments of Surma Basin. The complex geotectonic setting and obliquely subducting Indian Plate had controlled the evolution of the fold belt since Late Eocene. The NS trending hill ranges are comprised of Surma and Barail Group of rocks, with sporadic occurrences of Miocene Tipam Group along western margin of the belt. The lithounit of Bhuban and Bokabil Formation are comprised the most part of the basin with Barail Groups occurred only in the eastern region. In this study a sedimentological approach has been considered to understand the evolutionary development of the Mizoram Fold belt region during post depositional crustal dynamic processes. Petrographical study of the rock samples indicate multiple source region for the sediments. This results from the recycled-quartzose recycled orogenic settings that related to the subduction process surrounded by many orogenic belts. The sediments derived primarily from Himalaya ranges, with considerable contribution from Shillong plateau, Naga hill ophiolites and Indo-Burmese ranges were deposited in the basin under shallow marine conditions. The semi-humid to humid climatic conditions were also prevailed during that time. The continuous oblique subduction of Indian plate causes rise of the NS hill ranges of the fold belt. The thrusts formed during this upliftment phase were later transected by NNE-SSW and NW-SE trending strike slip faults that are also seismically active.

**Key words**: Mizoram Fold Belt, Provenance, Seismo-tectonic, Tectonic setting

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# Application of geo-spatial technologies for ground water quality mapping of Aizawl district, Mizoram, India

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## ABSTRACT

Water is one of the most important natural resources highly crucial for our day-to-day life. The main sources of water are surface water and ground water. Erratic and irregular availability of surface water leads to exploration and utilization of ground water for irrigation, industrial and domestic purposes. Therefore, the quality of ground water is equally important as its quantity. The present study utilizes geographical information system (GIS) technique to map the spatial variability of ground water quality. Ground water samples were collected from 188 point sources randomly distributed in Aizawl district, Mizoram. The major water quality parameters namely pH, electrical conductivity (EC), total dissolved solids, total hardness, iron, chloride, nitrate and fluoride have been estimated for all the sampling locations. The spatial variation maps of these ground water quality parameters were generated and utilize as thematic layers. These thematic layers were given ranks based on their relative importance. Different classes within each thematic layer were assigned weightages in numerical rating from 1 to 3 as attribute values in GIS environment. Summation of these attributes values and the corresponding rank values of the thematic layers were utilize to generate the final ground water quality map. This final map shows the different classes of ground water quality within the district which can be utilize to provide a guideline for the suitability of ground water uses.

**Key words**: GIS; ground water; water quality; Aizawl district.

## INTRODUCTION

The demand for water supply increases rapidly due to urbanization, growth of population and extensive uses in domestic and agricultural sectors.[1,2] Ground water is one of the most vital natural resources and the largest available source of fresh water.[3-5] Therefore, finding prospective areas for ground water, monitoring and conserving this resource have become highly crucial for the present civilization.[6,7]

Geologically, Mizoram state comprises N-S

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