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*Review*

# Crustal and Upper Mantle Structure of the Assam Valley Region, NE India: A Review of Geophysical Findings

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**Abstract:** The northeastern region of India is one of the six most seismically active convergent plate tectonic areas in the world. The north–south convergence along the Indo-Tibetan Himalayan Ranges and the east–west subduction within the Indo-Burma Ranges create a complex stress regime, resulting in significant seismic activity and a history of great/large earthquakes. The region's intricate strain patterns, active faults, and potential seismic gaps underscore the need for detailed subsurface studies to effectively assess seismic hazards and impending seismicity. Geophysical research is essential for understanding the region's geodynamic evolution, seismotectonics, and mineral resources. This manuscript reviews the geological and tectonic settings of the region and summarizes recent geophysical studies, including seismic, gravity, magnetic, and magnetotelluric surveys conducted in the Assam Valley and adjacent areas (within latitudes 24.5–28.5° N and longitudes 89–97.5° E). The review highlights key findings on hydrocarbon-bearing sediments, the configuration of the crystalline basement, the heterogeneous structures of the crust and upper mantle, and seismic discontinuities. By synthesizing these results, the review aims to enhance the understanding of seismic hazards in Northeast India, guide mitigation strategies, and identify key knowledge gaps to direct future research efforts.

**Keywords:** Northeast India; Assam Valley; Shillong Plateau; crustal structure; geophysical surveys; seismic hazard assessment



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## 1. Introduction

The Indian subcontinent, with a diverse tectonic setup ranging from stable shields to active orogenic and subduction zones, experiences intense seismic activity. Most of its major fault zones are considered active [1], posing substantial risks of large earthquakes. Given the potential for catastrophic seismic events, especially in densely populated areas, understanding and mitigating these risks requires focused, in-depth studies of specific regions to assess seismic hazards and develop effective mitigation strategies. Such research is essential for reducing seismic impacts and enhancing our understanding of regional tectonics.

The northeastern region of India, located between the Himalayan collision zone to the north and the Burmese subduction zone to the east, is characterized by a complex tectonic framework and stress regime, leading to high seismic activity [2–5]. Since 1869, this region has experienced two great earthquakes—the Mw ~8.3 1897 Shillong Plateau earthquake [6] and the Mw ~8.7 1950 Assam earthquake [7]—along with 25 large earthquakes with magnitudes of 7.0 or greater [8,9]. The entire region is classified as seismic zone V, indicating the highest seismic hazard level in India [10].

The region is traversed by the Brahmaputra River, which originates in southern Tibet and flows for 3410 km through China, India, and Bangladesh before emptying into the Bay of Bengal [11]. The Brahmaputra Valley in NE India, also known as the Assam Valley, stretches in an ENE-WSW direction and is flanked by two dynamic and youthful mountain belts. The valley is divided into three parts: the eastern Upper Assam Valley, the Central Assam Valley, and the western Lower Assam Valley [12]. The valley, particularly its eastern part, is known for rich hydrocarbon and mineral resources, underscoring its importance for economic development and energy production.

While the Assam Valley is a region of ongoing tectonic activity, its seismicity is relatively low compared to other areas in NE India. Notably, minimal seismic activity is observed in the section extending from the Kopili fault to the Mishmi thrust, known as the "Assam Gap" [13,14]. Based on the geometry of the source zones and the conventional definition of seismic gaps, some researchers [15–17] have argued that the "Assam Gap" is not a true gap in seismicity but rather an "aseismic corridor", suggesting that significant earthquakes are unlikely in this region. However, other studies [3,14,18,19] have identified this area as vulnerable to an impending large earthquake associated with the significant accumulation of stress energy. These contrasting views emphasize the need for further research to reassess the seismic risk.

Understanding the crustal and upper mantle structure is essential for comprehending tectonic evolution, assessing seismic hazards, and guiding resource exploration. This manuscript reviews the geological and tectonic setting of the region and compiles geophysical studies on the configuration of sedimentary deposits, the crystalline basement, the heterogeneous crust and upper mantle, and seismic discontinuities. While focusing on the Assam Valley, the study also considers the broader surrounding area, between latitudes 24.5° and 28.5° N and longitudes 89° and 97.5° E (Figure 1). By reviewing existing research and identifying key knowledge gaps, this work aims to provide a foundation for future studies that will improve seismic hazard assessments and resource exploration strategies in the region, contributing to more effective risk management and policy-making.

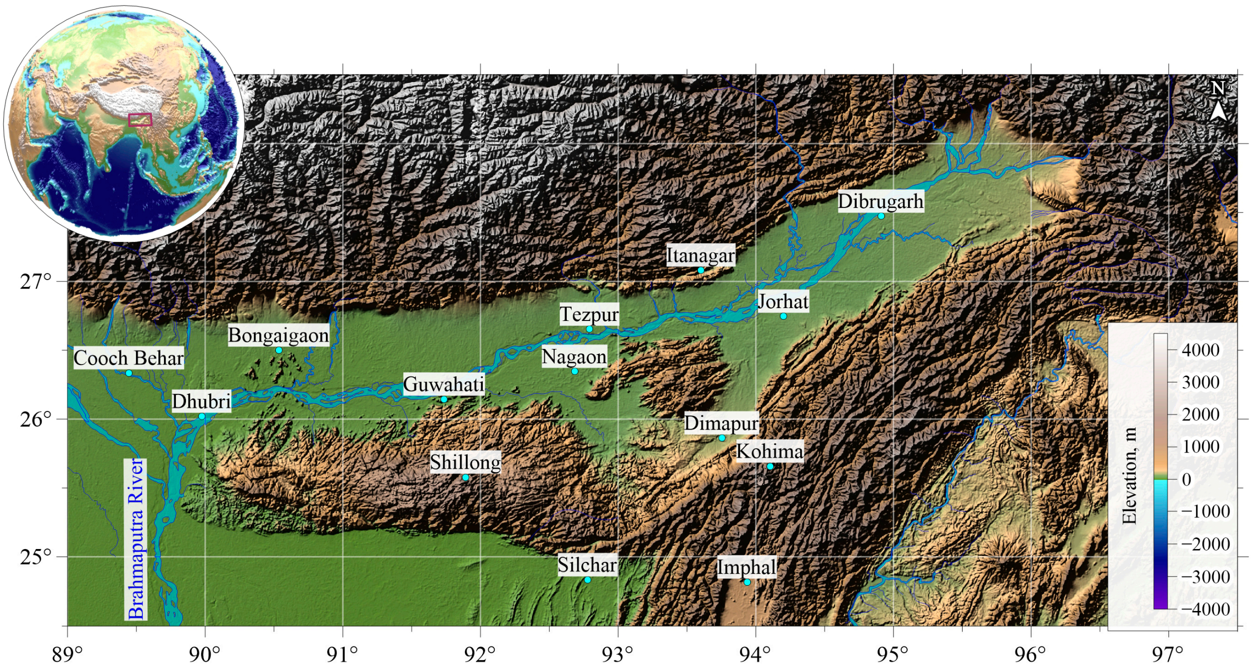


**Figure 1.** Topography of the study region [20]. Towns are marked with cyan dots. The rivers are from [21]. The inset in the upper left corner shows the location of the study area on the world map (outlined in red).

## 2. Regional Geological Setting

The Brahmaputra Basin is uniquely characterized by its polycyclic evolution, transitioning from a passive margin setting during the Paleocene–Oligocene to a foreland phase in the Miocene, and subsequently developing into an inter-mountain basin [22]. The stratigraphy of the basin has been comprehensively reviewed by [23–32]. According to Das Gupta and Biswas [26], the Assam Valley and its surrounding areas have undergone five significant phases of deformation throughout their geological history.

The initial phase corresponds to the onset of the plate tectonic cycle, when the study area, along with India, Tibet, Australia, Antarctica, Africa, and South America, was part of the Gondwana Supercontinent. During this period, the landmass primarily consisted of ancient metamorphic rocks from the Archaean to Early Proterozoic age, featuring various basic, ultrabasic, and acidic intrusions. The oldest rocks reported in the study area are the Precambrian granites and granite gneisses, which outcrop across the Shillong Plateau and Mikir Hills [25,27].

Phase two occurred during the Permian period, around ~250 Ma, when the Supercontinent began developing numerous rift valleys where coal-bearing Gondwana sediments were deposited. Phase three took place in the Late Triassic/Early Jurassic period, as Southern Tibet drifted away, opening the northern fringe of India to marine sedimentation.

Phase four commenced with the fragmentation of the eastern boundary during the Late Jurassic–Early Cretaceous period, allowing the southern and eastern shores of Assam to become exposed to marine sedimentation. This phase also marked the onset of igneous activity and the formation of basic and ultrabasic intrusions [33,34]. During the Paleocene sea transgression, the Jaintia Group (Early Paleocene to Late Eocene) was deposited in sequences of sandstone, limestone, and shale in shallow shelf environments that transitioned into marginal marine environments [30,35].

The fifth phase began with the collision of the Indian plate with Tibet to the north and Sunda to the east around the Early Eocene, initiating multiple phases of mountain building and the formation of mountain-front basins [36]. As elevations increased and sea levels receded, the Barail Group of sediments was deposited, ranging from deltaic to marginal marine environments, paving the way for the formation of significant economic mineral deposits.

During the Late Oligocene to Early Miocene, the collision of the Indian plate with the Eurasian plate led to significant tilting of the basin, the development of the Himalayan foreland, and the closure of remnant ocean basins [25,32]. Throughout the Paleogene to the Early Neogene epochs, the basinal slope of the Assam Shelf predominantly faced east and southeast, with the sedimentary column extending towards the Naga–Schuppen belt [37]. During the Lower-Middle Miocene, atop the Barail Group, the Surma Group of rocks was deposited, comprising intercalations of thin siltstones, sandstones, and shales [27,38].

During the Middle Miocene, the uplift of the Himalayas resulted in extensive erosion and the deposition of the fluvial Tipam Group of Late Miocene to Early Pliocene age. The Tipam Group comprises a lower arenaceous sandstone formation and an upper argillaceous clay formation [30]. During this period in the Assam Valley, significant compressional deformations such as thrusting and folding occurred, alongside the initial stages of exhumation of the Shillong Plateau [25,39]. The development of the Schuppen Zone, delineated by the Disang and Naga Thrusts, also took place during this time. By the Late Miocene, ongoing uplift of the Shillong Plateau caused the Brahmaputra River to shift its course from flowing east and south of the plateau to its current path along the northern edge [40].

On top of the Tipam Group, the Moran Group was deposited, comprising the sand–clay alternating sequence of the Namsang Formation from the Plio-Pleistocene age and the loosely consolidated sandstones with pebbly interbeds of the Dhekiajuli Formation, ranging in age from Pleistocene to Recent [27]. Following the deposition of Namsang sediments, there was a reversal in basinal slope. The Pleistocene to Recent Dihing Formation unconformably overlies the Moran Group, which itself is unconformably overlain by recent alluvial deposits. The regional schematic geological section along the Assam Valley and Shillong Plateau is provided in Figure 2.

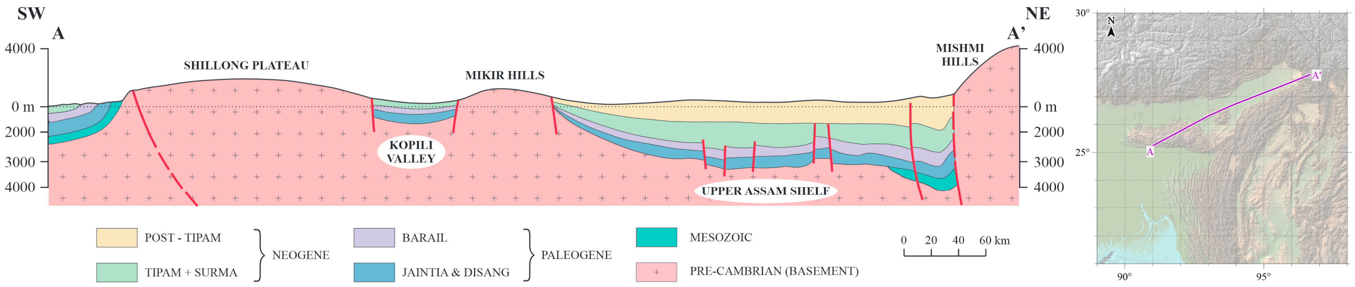


**Figure 2.** Schematic geological section across the Shillong–Mikir Plateaus and the Assam Valley, adapted from [26,27]. Red lines indicate faults.

## 3. Tectonic Setting and Seismicity

The NE Indian region is characterized by a complex tectonic environment resulting from two primary active processes: north–south convergence along the Himalayan orogenic belt and east–west subduction along the fold and thrust belts of the Indo-Burma Ranges (Figure 3). The Indian plate is considered to underthrust the Eurasian plate along a gently inclined plane [41,42] and subduct beneath the Burmese micro-plate at steeper dip angles greater than 30° [42–45]. These interactions result in a complex triple junction of the three plates, forming the Eastern Himalayan Syntaxis (EHS) zone [46], with the Assam Syntaxis identified as an independent part of it [47,48].

The region was classified into distinct seismotectonic zones based on factors such as tectonic activity, movement direction, movement rate, and fault mechanisms [5,49–52]. The major distinct tectonic domains identified in the region (Figure 3) include the Eastern Himalaya (Sikkim, Bhutan, Arunachal), the Indo-Burma Ranges, the Assam (Brahmaputra) valley, the Shillong–Mikir Plateaus, and the Assam Syntaxis [53,54].

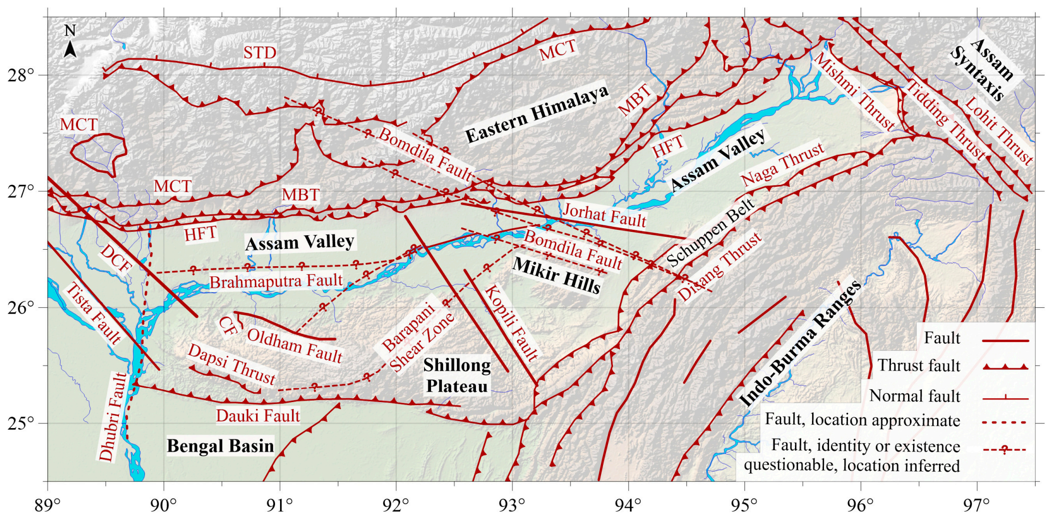


**Figure 3.** Tectonic setting of NE India, adapted from [4–6,45,53,55–61]. Major faults are shown with red lines. Seismotectonic zones are highlighted in bold font. Abbreviations: HFT—Himalayan Frontal Thrust; MBT—Main Boundary Thrust; MCT—Main Central Thrust; STD—South Tibetan Detachment; DCF—Dhubri–Chungtang Fault Zone; CF—Chedrang Fault.

The northern boundary of the ENE-WSW-stretching Assam Valley is delineated by the Himalayan arc, marked by the Himalayan Frontal Thrust (HFT). To the northeast, the valley is bordered by the Assam Syntaxis and the southwest-verging thrusts of the Mishmi block. The southern boundary is defined by the Indo-Burmese Arc to the east (Naga–Disang thrust) and the Shillong and Mikir plateaus to the southwest (spanning from 90° E to 94° E longitude).

Compared to other zones in NE India, the Assam Valley experiences relatively low seismicity (Figure 4), with the Kopili fault zone being the main source of intra-plate earthquakes in the area [3]. Notably, the Assam Gap, which spans from the Kopili fault to the Mishmi thrust, shows minimal seismic activity [13]. While some researchers argue that this area is aseismic [15–17], others suggest that significant stress accumulation over time could result in a major earthquake in the near future [3,14,18,19].

GPS (Global Positioning System)-based studies suggest that NE India has a different pattern of tectonic movement than the Indian shield [54,62–66]. According to Vernant et al. [63], the Assam Valley has separated from the Indian plate and is rotating clockwise relative to India around a point located a few hundred kilometers west of the Shillong Plateau (Figure 4). The Kopili fault divides the valley into two distinct blocks, with the eastern Assam block moving southward at a slightly faster rate than the western Shillong block, resulting in 3 mm/yr (or more) of dextral shear across the Kopili fault zone [63,64,66]. This rotation decreases convergence across the Himalaya east of Sikkim from 18 mm/yr to around 12 mm/yr, while convergence between the Shillong Plateau and Bengal basin increases from 3 mm/yr to over 8 mm/yr. The southern edge of the Assam block collides with the Naga Hills at 1–3 mm/yr and descends beneath them. Meanwhile, the Shillong block is thrust over oceanic crust to the south, tilting gently northward, with significant deformation occurring only along its southern edge [63]. The western edge of the Mikir Hills massif appears to be locked to the Assam block, suggesting strain accumulation [64].

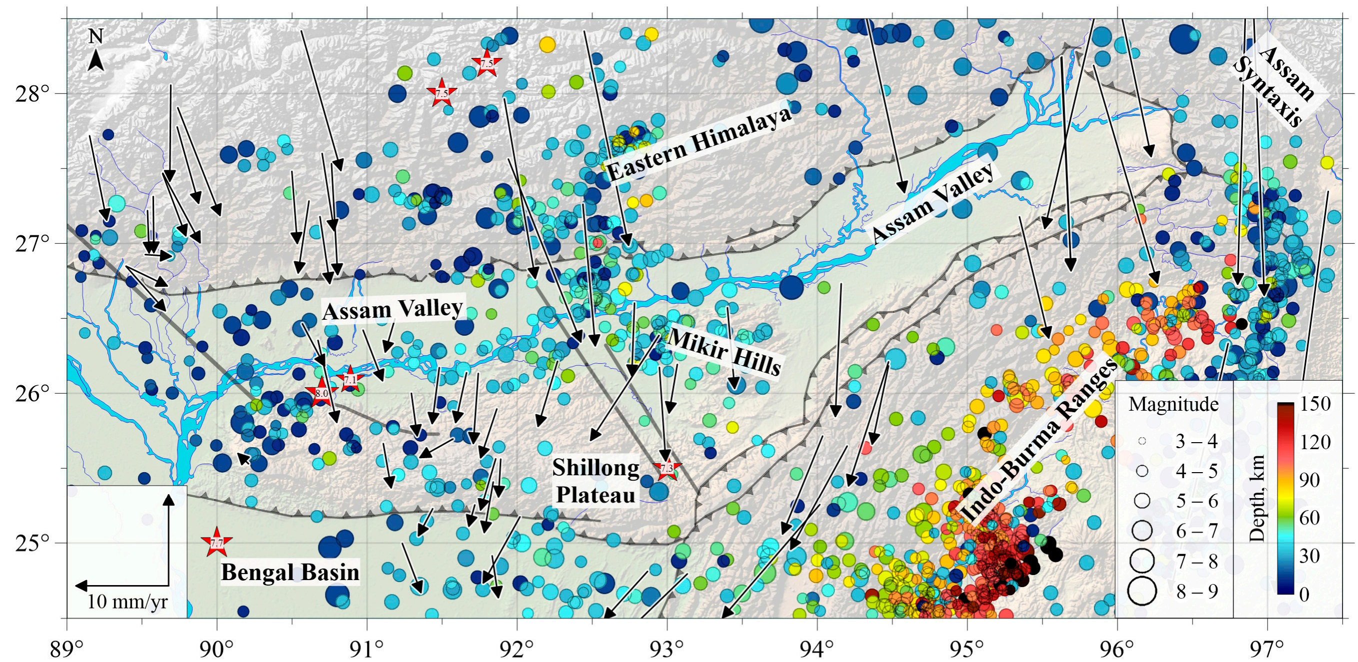


**Figure 4.** Seismicity map of the study area along with GPS vectors (Indian plate fixed) from [63]. Earthquake events from the United States Geological Survey catalog (1904–2024) [67] are represented by circles, with size corresponding to magnitude and color indicating depth. Red stars denote events from the Global Historical Earthquake Archive (1000–1903) [68], with labels indicating magnitude. Major tectonic lines are taken from Figure 3.

The east-dipping Kopili fault is a 50 km wide, NW-SE-trending active transverse zone responsible for significant seismic activity, including the Mw 7.4 earthquake in 1869 and the Mw 7.2 earthquake in 1943 [69–72]. It separates the Shillong Plateau from its fragmented part, the Mikir Hills, and cuts across the Assam Valley, possibly extending from the HFT on the Himalayan side to the Belt of Schuppen on the Indo-Burman side [4,53,73]. Seismic activity along the Kopili fault extends to depths of ~50 km, with earthquakes primarily resulting from normal or strike–slip faulting mechanisms [8,74,75]. According to [75], the fault zone has a slight eastward dip with a dip angle of ~80°. GPS data analysis indicates an east–west convergence of ~2 mm/year across the fault, suggesting its transpressional nature [76]. A best-fit elastic dislocation model estimates a right-lateral slip rate of 2.62 $\pm$ 0.79 mm/year at a locking depth of 3 $\pm$ 2 km [76]. This slip contributes to seismic moment accumulation, suggesting the potential for future earthquakes with magnitudes of 5.2 [76] or even greater than 7.0 [73,77].

The Bomdila Fault, located east of the Mikir Plateau, is another significant active fault in the region [58,78]. It dips towards the NNE at an average angle of ~50–55° [74] and may extend in a WNW-ESE direction from the Belt of Schuppen to the Main Central Thrust. However, its extent remains debated, with varying estimates reported [56,58,60,79] (Figure 3). The fault is seismogenic, with the northern segment showing higher activity compared to the southern segment [74]. Strain distribution patterns suggest that the fault is associated with compressional tectonics, leading to reverse-fault earthquakes [58].

The uplifted horst-like structure of the Shillong Plateau [80,81] and its eastern extension into the Mikir Hills, located south of the Central Assam Valley, are the sources of intense seismicity of the region [3,82–84]. Notably, the great 1897 Shillong (Assam) earthquake (Mw ~8.3) occurred at the northwest edge of the plateau [6,59]. Earthquakes from this area exhibit focal depths of up to 50 km [82], likely influenced by pop-up tectonics involving thrust or reverse faulting with a strike–slip component [8]. The east–west-trending, northward-dipping Dauki fault marks the southern edge of the Shillong Plateau, separating it from the Bengal Basin [83]. Mitra et al. [85] indicate that this fault can produce a ~20 m slip, resulting in an Mw $\sim$8 earthquake. Further investigations are needed to better understand the northern boundary of the plateau, proposed as the Brahmaputra or Oldham fault, whose existence and geometry remain widely debated [59,86–90].

In the northeastern boundary of the Assam Valley, within the Assam Syntaxis zone, seismic activity extends to depths of ~40 km. The area's seismogenesis and geodynamic evolution are significantly influenced by indentation tectonics and continuum flow models. According to Hazarika et al. [91], the closely spaced Mishmi, Tidding, and Lohit faults are steeply dipping thrust sheets that accommodate significant crustal shortening resulting from indentation and clockwise rotational tectonics. Additionally, the Walong fault exhibits strike–slip motion, facilitating the clockwise rotation of crustal material around the syntaxis.

## 4. Mineral Resources

Oil exploration in Assam began with early geological efforts in the 1820s and transitioned to commercial activity by the late 19th century [92–94]. Advances in seismic techniques subsequently led to the discovery of over 100 petroleum fields within the Assam Valley, mainly south and southeast of the Brahmaputra River, with limited investigation in the northern part [30,95–98]. While parts of the Upper Assam Valley appear to have reached an intermediate stage of exploration maturity, the Dhansiri Valley shelf, the Himalaya and Mishmi foothills, and the Naga–Schuppen belt remain in the early stages [97]. Consequently, the Assam Valley may still contain substantial untapped oil reserves.

Beyond oil, Assam has modest reserves of natural gas and is notably rich in coal deposits, particularly in Upper Assam, the Karbi-Anglong district, and the Sukchar–Singrimari area [30,99]. The region also contains a diverse range of minerals, including base metals, limestone, glass sand, clay, feldspar, mica, beryl, gypsum, iron ore, placer gold, pyrite, salt, sillimanite, graphite, rare earth elements (REEs), and more. However, the economic significance of these minerals remains unexplored [30,100].

## 5. Geophysical Exploration of Sedimentary Deposits

Understanding the sedimentary deposits of the Assam Valley is essential for several key reasons, with hydrocarbon exploration being a primary focus. Geophysical studies in the region have mainly employed active seismic surveys and borehole logging. However, research has predominantly concentrated on the Upper Assam Valley, leaving other areas relatively underexplored. The following summary highlights several recent significant studies in this field.

Mandal and Dasgupta [101] utilized regional seismic sections to investigate the dynamic evolution and depositional history of the Upper Assam Basin, focusing on the area from east of Jorhat to the Assam Syntaxis. The seismic images revealed sediment deposition through three distinct stages of basin development. Their findings validated the previously proposed basin model [98], indicating that the basin dipped towards the east, southeast, and south following the collision of the Indian and Burmese plates, with sediments primarily coming from the north and northeast. During the late Miocene and Pliocene, the basin tilted towards the north and northeast, with uplift occurring in the central part. Compressional forces from the north, east, and south—likely driven by ongoing plate motions—continue to influence neotectonic activity in the basin's foreland.

Gogoi and Chatterjee [95] assessed petrophysical parameters in the northern Upper Assam Basin using well logging and seismic data, focusing on sand reservoirs within the Tipam Sandstones (middle Miocene) and Barail Arenaceous Sandstones (Oligocene). Their approach involved mapping geological formations, creating a porosity wavelet from seismic data (as detailed in [102]), generating porosity sections, and applying neural network modeling to evaluate shale volume and water saturation. The methodology included well-log analysis, integrating synthetic models with seismic data, and performing acoustic impedance inversions. The study estimated average porosities of 30% to 36% for the Tipam Sandstones and 18% to 30% for the Barail Arenaceous Sandstones.

Rai et al. [103] conducted a detailed 3D seismic study on the Upper Assam shelf, focusing on the area between the Mikir Hills and the Naga Thrust. Their study covered a 34 $km^2$ area, located between latitudes 26°14′ N and 26°22′ N, and longitudes 93°56′ E and 94°2′ E. The analysis of impedance and porosity volumes assessed the hydrocarbon potential in the Paleocene to lower Oligocene sands and the Precambrian basement. The study identified potential reservoir rocks in the Sylhet, Kopili, and Barail formations, with the Sylhet and Kopili formations showing the most significant potential. Near the Naga Thrust belt, potential reservoirs were also predicted in the Kopili formation, Sylhet formation, and the fractured basement.

Narayan et al. [32] presented an integrated methodology to delineate the thin and discrete sand reservoir facies from shale-dominated Kopili formation in the Lakwa oil field of the Upper Assam Basin. Their approach involved post-stack seismic inversion, predicting total porosity, and litho-facies. Combining electro-log-based litho-facies interpretation and analyses of seismic-derived attributes, the study affirmed the presence of thicker sand facies in the Upper Kopili and thinner, interbedded sand facies in the Lower Kopili. The lateral and vertical variabilities in reservoir facies distribution identified through reservoir characterization directly influence estimates of oil and gas reserves.

Kumar et al. [104] utilized 3D seismic reflection data, covering an area of ~370 $km^2$ in the Upper Assam Valley west of Dibrugarh, to obtain precise subsurface imaging and characterize the geological evolution and petroleum system framework of the survey region. Their study delineated the geometry and kinematics of faults, predominantly displaying an NE-SW orientation. Sinistral strike–slip motion was identified in the southeastern and southwestern regions. Structural features such as extensional horsetail splay faults, negative flower structures, and minor transfer faults indicated significant lateral movements along these faults. The study further noted that tectonic tilting of the basin, coupled with sediment loading from adjacent fold-and-thrust belts over geological time, has structurally modified the basin's configuration, resulting in the observed strike–slip deformations.

## 6. Geophysical Studies of Basement Configuration

Understanding the configuration of the crystalline basement is essential for regional mineral resource exploration, seismic hazard assessment, and comprehending the region's tectonic evolution. Furthermore, accurate data on sediment structure and thickness are crucial for effective ground motion modeling and site-specific hazard assessments [105]. However, most boreholes drilled in the region have not reached the basement, so insights into its depth and structure primarily rely on geophysical studies, predominantly involving seismic, gravity, and magnetic surveys.

Saikia et al. [12] analyzed receiver functions (RFs) and modeled the shear wave velocity (Vs) structure using data from ten broadband seismic stations across the Assam Valley. Their study highlighted significant variations in sedimentary thickness across the valley, Shillong Plateau, and Himalayan foredeep, ranging from 0.5 to 6.5 km, with thickness increasing from southwest to northeast (Figure 5). Borgohain et al. [106] performed teleseismic RF modeling, revealing sedimentary thicknesses of 0.2–0.6 km under the western Shillong Plateau, 0.2–1.0 km beneath Shillong town, 0.4–3.1 km in the western Assam Valley, and ~4.1–6.2 km beneath the Lesser Himalaya region.

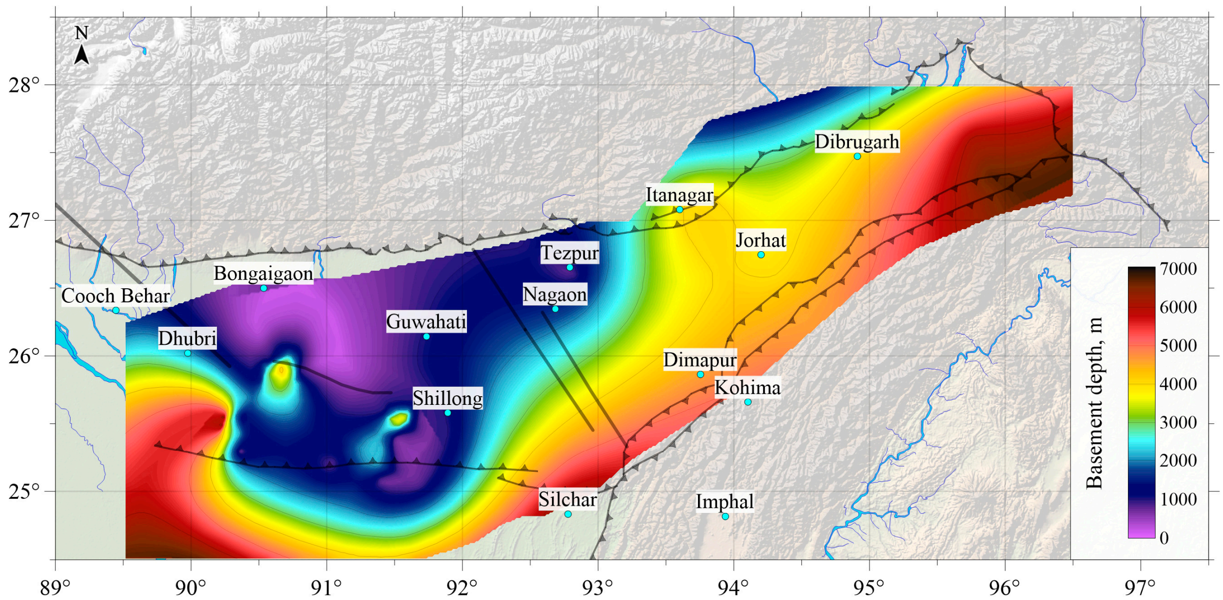


**Figure 5.** Depth to the top of the basement in the study area, as estimated from RF analysis, adapted from Saikia et al. [12]. Major tectonic lines are taken from Figure 3.

Further south, Ravi Kumar et al. [43] estimated the basement depth within a broad part of the NE Indian region using radially averaged power spectral analysis of Bouguer gravity data. Their findings indicated basement depths ranging from 1.2 km to 6.3 km, with relatively shallow depths in the Shillong Plateau, moderate to greater depths in the

Belt of Schuppen, and the deepest basement in the eastern and southeastern parts of the Indo-Burma Ranges.

Detailed investigations have been carried out in the oil-rich Upper Assam Valley. Kumar et al. [107] analyzed data from 230 drilled wells, 4550 km$^2$ of 3D seismic surveys, and 1400 km of 2D seismic surveys to construct a comprehensive basement depth map east of Dibrugarh town. Their findings revealed that the basement slopes towards the south, southeast, and northeast, with maximum depths reaching approximately 7 km in the basin's shelf region. They also identified two distinct fault systems, Eocene and post-Eocene, and developed regional geological cross-sections. In the Sadiya Block area (~450 km$^2$), detailed basement configuration was derived using gravity, magnetic, and seismic data by Ghosh et al. [108]. The study revealed various positive structural features that could potentially guide future hydrocarbon exploration efforts. The density model indicated a fault-controlled undulating subsurface, with basement depths reaching up to 6 km in the southeast and between 4 and 4.5 km in the northwest and northeast.

South from the Upper Assam Valley, within the Schuppen Belt area, Saha [109] investigated the thick Gondwana sediments and basement structure using gravity, magnetic, and seismic data. The study indicated a rapid increase in sediment thickness beneath the Naga Thrust, though additional data were needed for verification due to limited measurement data. Ravi Kumar et al. [110] extended the basement mapping to the broader Kohima Synclinorium and adjacent inner fold belts, revealing significant variability in the gravity-derived basement structure. Their 2D gravity modeling, constrained by seismic data, indicated basement depths ranging from 2.2 to 3.5 km below the Assam Valley and from 3.5 to 5.5 km beneath the Schuppen Belt.

In the central part of the Brahmaputra basin, the basement configuration of the Kopili Valley area was studied by Singh [111] through the integration of gravity, magnetic, and seismic data, estimating a maximum sedimentary thickness of 1.3 km. Pathak et al. [112] expanded on this by estimating basement depths to range from less than 0.5 km to 1.5 km, deepening towards the north and northeast. They also identified numerous lineaments and weak zones prone to intense seismic activity.

To analyze the structural setup of the Shillong Plateau and to construct a basement depth map of the area, aeromagnetic data were analyzed by Sharma et al. [113]. Their research identified major geological features, including faults, fractures, contacts, shears, and magnetic bodies, predominantly within the top two layers, extending to a maximum depth of 3.7 km below the observation plane. The results revealed a heterogeneous magnetic basement characterized by undulations and varying depths of uplifts and downthrows.

## 7. Geophysical Studies of the Crust and Mantle

To comprehend the geodynamic evolution, seismogenesis, and hazard potential of active regions, it is crucial to study their crustal and upper mantle configuration. In NE India, deep geophysical studies have primarily utilized passive seismic methods [114–116] to reveal subsurface seismic velocity distributions, Poisson's ratio variations, and the geometry of seismic discontinuities. Gravity studies have provided insights into the Moho (Mohorovičić discontinuity) depth and the presence of high-density mafic/ultramafic intrusive bodies. Although limited, magnetotelluric studies have contributed valuable information about fault geometry and the electrical resistivity properties of the heterogeneous crust.

### *7.1. Crustal Thickness*

The spatial distribution of Moho depth, marking the boundary between the Earth's crust and mantle, has been extensively studied in NE India, primarily using passive seismic techniques. The region's collision and subduction tectonics have resulted in significant variations in crustal thickness. Rai et al. [117] reported Moho depths of 45–49 km beneath the Shillong Plateau, with a significant thickening beneath the Mikir Hills and the Assam Valley. In contrast, Kumar et al. [118] identified a relatively uniform crustal thickness of ~35 km for the Assam Valley, Shillong Plateau, and Mikir Hills. Ramesh et al. [119] observed a northward-dipping Moho starting at Tezpur and reaching depths of around 50 km in the sub-Himalayas. Mitra et al. [41] found the thinnest crust beneath the Shillong Plateau at 35–38 km, deepening by 5–7 km in the Assam Valley. Kosarev et al. [120] estimated a Moho depth of ~35 km near Shillong town. Using inversion of travel-time residuals, Bora et al. [121] estimated a shallower Moho depth of 33–35 km in the central part of the Shillong Plateau and a deeper Moho depth of 39–41 km in most parts of the Mikir Hills and Assam Valley. Using receiver function analysis, Bora et al. [122] observed crustal thicknesses of 34–38 km beneath the Shillong Plateau, increasing to 37–38 km beneath the Assam Valley and 46–48 km beneath the Lesser Himalaya. Borah et al. [123] suggested a crustal thickness of 32–36 km beneath the Shillong Plateau, increasing to ~38–40 km beneath the Assam Valley and ~44 km beneath the Lesser Himalaya. Anand et al. [124] reported crustal thicknesses of 30–35 km beneath the Shillong Plateau, 36 km beneath the Mikir Hills, and 38–41 km beneath the Assam Valley. Mitra et al. [85] suggested a remarkably thin crust of 30 $\pm$ 2 km beneath the central Shillong Plateau and Mikir Hills, with crustal thickness increasing by 8–10 km towards the Assam Valley (with a $\sim$30° north-dipping Moho flexure) and by 12–13 km south of the plateau, across the Dauki fault. Agrawal et al. [125] reported a $\sim$35.5 km Moho in the westernmost Assam Valley and a gradual E-W increase from 29 to 35 km within the Shillong Plateau. Within the Assam Syntaxis zone, Kundu et al. [126,127] found that the crustal thickness increases from 47 km beneath the Assam Valley to ~55 km in the western part of the Lohit complex. Saikia et al. [128] and Bora et al. [129] showed that within the Naga–Disang thrust, the Moho deepens southwest from ~42 to 50 km. Shukla et al. [9] confirmed a thinner crust beneath the Shillong Plateau and Mikir Hills (34–36 km) and an increase in the Assam Valley (~36–42 km), further thickening in the Himalaya and Mishmi Hills (>45 km) and the Indo-Burma Ranges (up to 54 km). Their map illustrating the regional variation in crustal thickness, incorporating previously published findings, is shown in Figure 6. The most recent study by Arora et al. [130] aligns with previous findings, showing that the Moho deepens gradually from less than 35 km in the center of the Shillong Plateau to 37–39 km in the western part of the Plateau and in the Assam Valley. The Moho depth estimates reviewed in this section are summarized in Table 1.

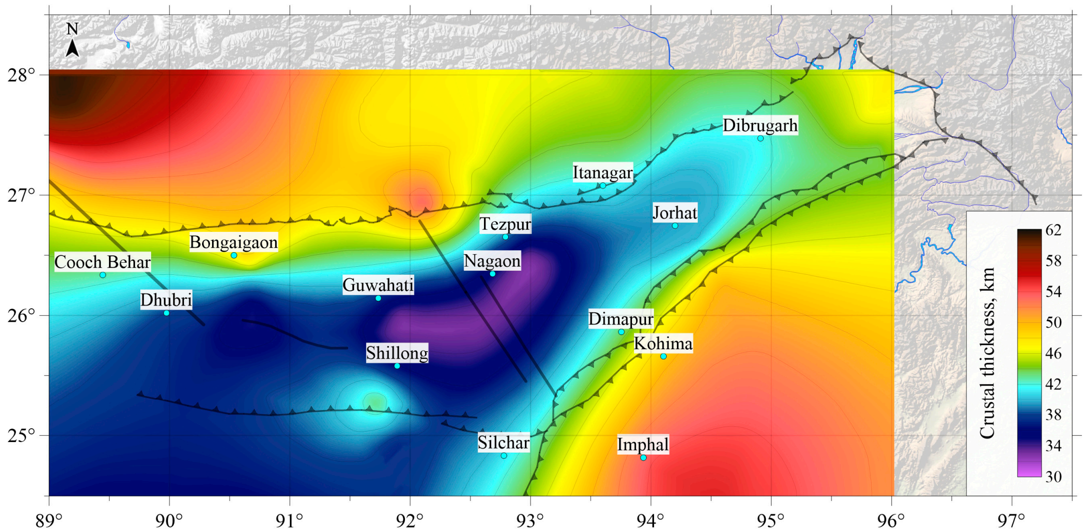


**Figure 6.** Crustal thickness across the study area based on RF analysis, adapted from [9,41,85,118,123,126,128,131,132]. Major tectonic lines are taken from Figure 3.

**Table 1.** Comparison of Moho depth estimates from various studies.

| Region | Moho Depth (km) | Study Method | Reference |
|---|---|---|---|
| Shillong Plateau | 45–49 | P-arrival times, travel-time residual | Rai et al. [117] |
| | ~35 | RF analysis | Kumar et al. [118] |
| | 35–38 | RF analysis | Mitra et al. [41] |
| | ~35 | RF analysis | Kosarev et al. [120] |
| | 33–37 | Inversion of travel-time residuals | Bora et al. [121] |
| | 34–38 | RF analysis | Bora et al. [122] |
| | 32–36 | Joint inversion of surface wave (SW) dispersion and RF | Borah et al. [123] |
| | 30–35 | Joint inversion of SW dispersion and RF | Anand et al. [124] |
| | ~30 | Joint inversion of SW dispersion and RF | Mitra et al. [85] |
| | 29–35 | Joint inversion of SW dispersion and RF | Agrawal et al. [125] |
| | ~33–40 | RF analysis | Shukla et al. [9] |
| | 35–37 | RF analysis | Arora et al. [130] |
| Mikir Hills | ~33 | RF analysis | Kumar et al. [118] |
| | 37.5–38.5 | Inversion of travel-time residuals | Bora et al. [121] |
| | 36 | Joint inversion of SW dispersion and RF | Bora et al. [121] |
| | ~30 | Joint inversion of SW dispersion and RF | Mitra et al. [85] |
| | 34–36 | RF analysis | Shukla et al. [9] |
| Assam Valley | 40–60 | P-arrival times, travel-time residual | Rai et al. [117] |
| | ~35 | RF analysis | Kumar et al. [118] |
| | ~35 | RF analysis | Ramesh et al. [119] |
| | 40–42 | RF analysis | Mitra et al. [41] |
| | 35–41 | Inversion of travel-time residuals | Bora et al. [121] |
| | 37–38 | RF analysis | Bora et al. [122] |
| | 38–40 | Joint inversion of SW dispersion and RF | Borah et al. [123] |
| | 38–41 | Joint inversion of SW dispersion and RF | Anand et al. [124] |
| | 36–42 | Joint inversion of SW dispersion and RF | Mitra et al. [85] |
| | 35.5 | Joint inversion of SW dispersion and RF | Agrawal et al. [125] |
| | 36.5–41.5 | RF analysis | Shukla et al. [9] |
| | 37–39 | RF analysis | Arora et al. [130] |
| Arunachal Himalaya | >45 | RF analysis | Kumar et al. [118] |
| | 50 | RF analysis | Ramesh et al. [119] |
| | ~48 | RF analysis | Mitra et al. [41] |
| | 46–48 | RF analysis | Bora et al. [122] |
| | 44 | Joint inversion of SW dispersion and RF | Borah et al. [123] |
| | ~45 | RF analysis | Shukla et al. [9] |
| | 43–45 | RF analysis | Arora et al. [130] |
| Assam Syntaxis | 50–55 | RF analysis | Kundu et al. [126,127] |
| Naga–Disang thrust | 42–50 | RF analysis | Saikia et al. [128] |
| | 42–50 | RF analysis | Bora et al. [129] |
| | 43–46 | RF analysis | Arora et al. [130] |

### *7.2. Seismic Studies of the Lithosphere*

RF analysis [85,123–125,129,133] estimated the average crustal shear wave velocity beneath the Shillong Plateau, Assam Valley, and Indo-Burma Ranges to be ~3.3–3.5 km/s, with a slight increase observed in the Lesser Himalaya. This is lower than the 3.75 km/s average beneath the Indian shield. In the northern Bengal Basin, the average Vs is about 4 km/s [85,132].

Poisson's ratio in the region varies significantly, ranging from 0.23 to 0.3. The average Vp/Vs ratio in the Shillong Plateau and Assam Valley is estimated to be between 1.7 and 1.8, suggesting a felsic or felsic-to-intermediate crustal composition, indicative of a continental origin [9,85,123,125]. However, the observed east–west variations across the Assam Valley and between it and the Shillong Plateau may require further validation [85,130]. Higher Vp/Vs values are reported in the Lesser Himalaya, Indo-Burma Ranges, and Assam Syntaxis [9,123,129], with some extreme values in the Assam Syntaxis indicating the presence of fluids or partial melt [126]. The combination of high Vs and Vp/Vs values, along with intermediate crustal thickness in the northern Bengal Basin, is interpreted as evidence of transitional crust with oceanic affinity [85,130,132].

Beneath the central part of the Shillong Plateau, Mitra et al. [41] identified a high-velocity layer (Vs ~3.7 km/s) in the upper 10 km, followed by a less prominent ~7 km thick low-velocity layer (Vs ~3.2 km/s). Subsequent studies [122,123,130] confirmed these layers and observed their deepening towards the western Plateau and into the western Assam Valley, with the high-velocity layer potentially extending into the Lesser Himalaya (Figure 7). Bouguer gravity analysis validated the high-velocity antiformal geometry layer, modeling it as a high-density structure [130]. This layer is interpreted as a pre-Himalayan feature deformed by both northward and southward tectonic forces, possibly aiding in the uplift of the plateau [130]. The low-velocity layer, analyzed with distinct back azimuths at the central part of the Plateau, was explained by the underthrusting of Bengal Basin sediments at the Dauki fault zone [122].

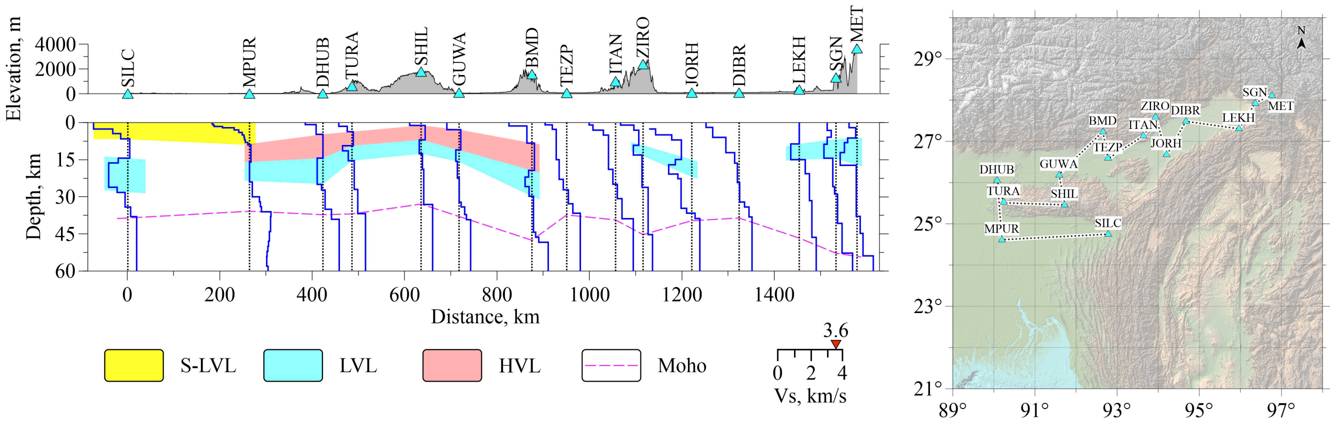


**Figure 7.** Shear wave velocity models from RF analysis (represented by blue lines), modified from Arora et al. [130], along with the corresponding topography. The highlighted profile structures include the low-velocity sedimentary cover (S-LVL) shown in yellow, the crustal low-velocity layer (LVL) in light blue, and the upper crustal high-velocity layer (HVL) in pink. The Moho is depicted with a dashed purple line. The right panel shows the locations of seismic stations (triangles) and the profile path (dashed black line).

Seismic tomography studies have provided further insights into the 3D lithospheric structure of the study region. Early research, using limited datasets, revealed strong heterogeneity in both lateral and vertical directions, corresponding with major tectonic features [134,135]. The subsequent development of digital broadband station networks has significantly improved data quality and quantity.

The inversion of P- and S-wave arrival times from local and regional events by Raoof et al. [42] revealed an NE-SW trending high Vp and Vs structure in the Assam Valley foredeep, interpreted as a buckled section of the Indian lithosphere "caught in the vice-like grip" between the Himalayan and Indo-Burmese arcs (Figure 8). The Shillong–Mikir Plateaus were identified as the most intense positive velocity anomalies within the crust. Beneath the Mikir Hills, at depths of ~35–50 km, a narrow low-velocity zone was detected, suggesting that the top of the buckled lithosphere had fractured and been partially underthrust by low-velocity material. At ~20 km depth, an NW-SE-trending low-velocity zone was found, separating the Mikir Hills from the Upper Assam Valley and aligning with the Bomdila and Jorhat fault. This anomaly appears to deepen to the northeast, towards the Assam Syntaxis, potentially explaining the low seismic activity in the Upper Assam Valley due to reduced resistance to subduction/underthrusting processes. High Vp and low Vs values were detected in the Assam Syntaxis, consistent with findings from RF analysis [126,127]. The Eastern Himalayas and Indo-Burma Ranges, bordering the foredeep, were characterized by dipping Vp and Vs anomalies related to the underthrusting Indian lithosphere.

Kumar et al. [136] employed Rayleigh wave tomography with a 1 × 1° grid spacing to study the NE India region, revealing smooth Vs distributions to a depth of 90 km. Their results are consistent with previous seismological findings. High-velocity near-surface crystalline rock bodies were identified in the Shillong–Mikir Plateaus, while the Upper Assam Valley was characterized by a sediment layer ~4–6 km thick. A sharp velocity contrast was noted across the Dauki fault. In the Bengal Basin, the sedimentary layer thickness varied from ∼10 km in the west to ∼21 km in the east. High Vs beneath the Shillong–Mikir Plateaus suggests an uplifted crust and uppermost mantle, buckled between the Himalayan and Indo-Burmese arcs.

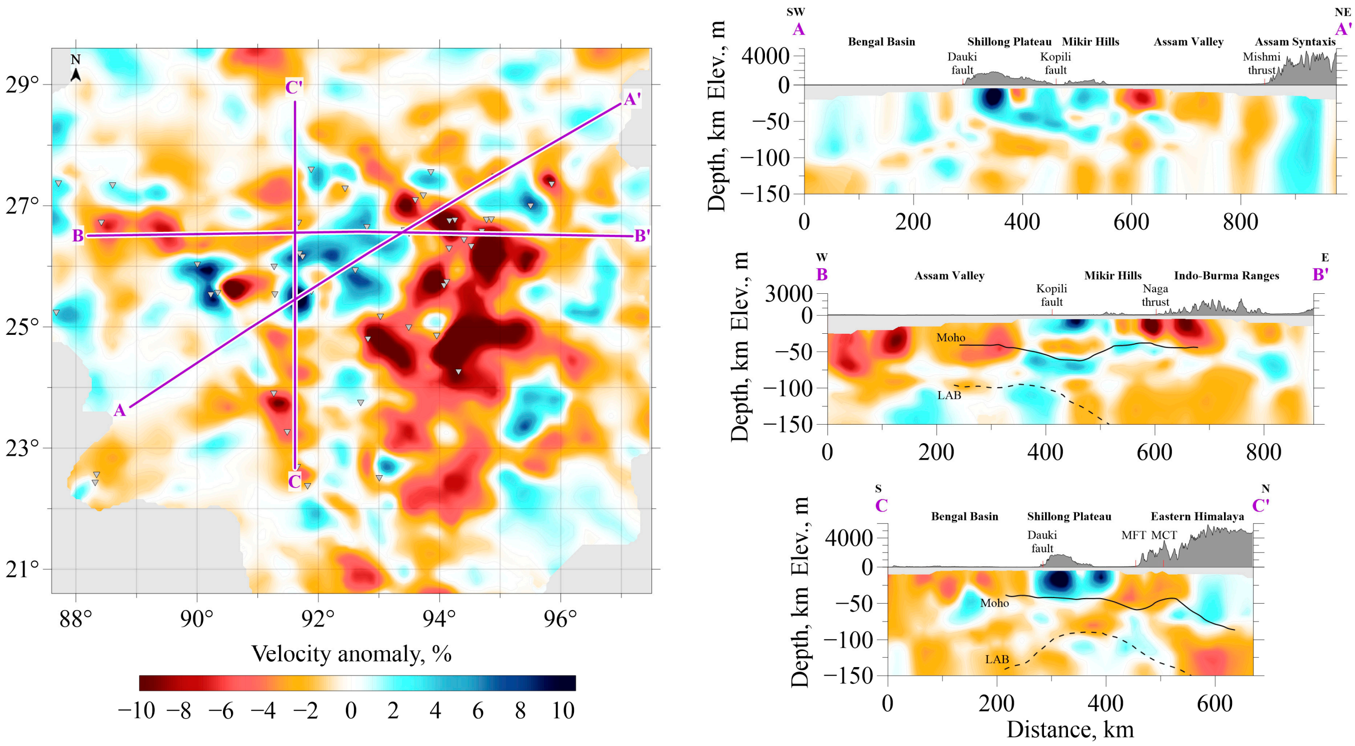


**Figure 8.** Vp tomographic images, adapted from Raoof et al. [42]. The left panel shows a map view at a depth of 20 km, while the right panels present vertical sections with topography along three cross-sections. The cross-section locations are marked by purple lines on the map. Seismic stations are indicated by gray triangles. The Moho and LAB, as estimated by Devi et al. [137], are shown in the vertical sections with solid and dashed black lines, respectively.

P-wave tomography conducted by Mishra [138] using a comparatively limited dataset revealed smooth velocity distributions in the NE India and Indo-Burma regions (Figure 9). Vp anomalies showed a strong correlation with the region's collision and subduction tectonics. High-velocity zones indicated the underthrusting of the Indian plate beneath the Indo-Burmese Arc, while low-velocity zones were linked to thick Bengal Basin sediments, potentially underthrusting beneath the Shillong Plateau. Additionally, low-Vp zones were identified in the upper crust along the Dudhnoi, Chedrang, and Kopili faults, as well as the Barapani shear zone.

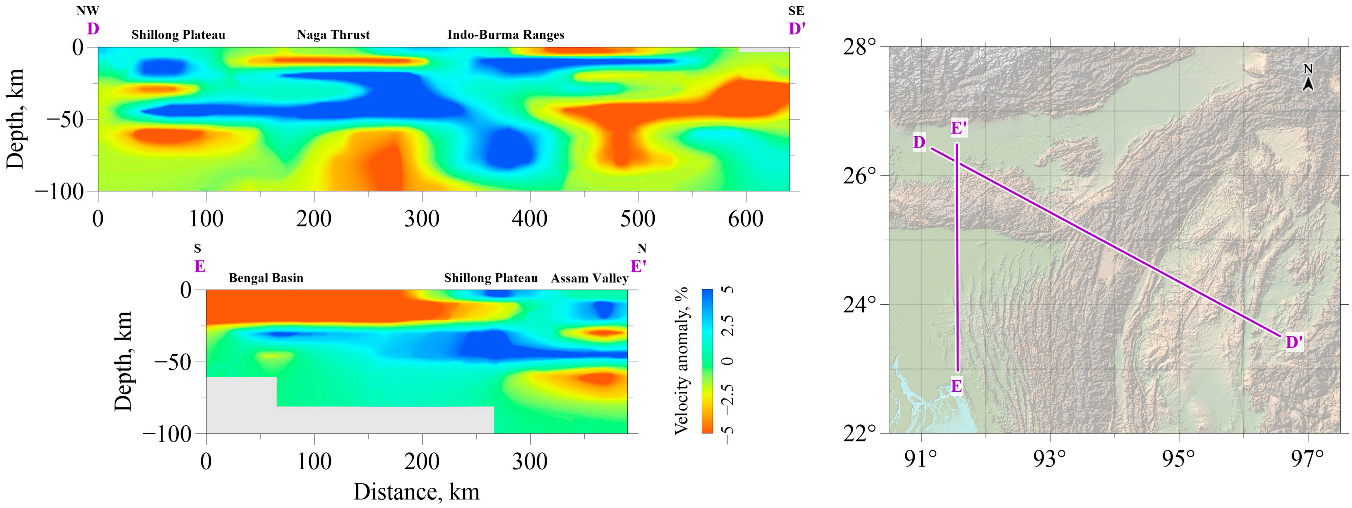


**Figure 9.** P-wave tomography cross-sections, adapted from Mishra [138], with the locations of the cross-section lines shown in the right panel.

Singh et al. [39] further investigated the subsurface structure beneath the Shillong Plateau down to a depth of 60 km. By inverting data from 670 events, they revealed a complex pattern of Vp, Vs, and Poisson's ratio anomalies. The Dauki fault, Oldham fault, and Barapani shear zone were correlated with the boundaries of low- and high-velocity zones. In the uppermost mantle, low seismic velocities and high Poisson's ratios were prominent beneath the plateau, aligning with findings by Raoof et al. [42]. Their results support the pop-up tectonics of the plateau [8,139,140], suggesting that the uplift occurs between the Dapsi thrust in association with the Dauki fault in the south and the Brahmaputra fault in the north.

### *7.3. Seismic Studies of the Upper Mantle*

RF analysis indicates that the uppermost mantle Vp beneath the Assam Valley and Shillong Plateau ranges from 7.5 to 7.8 km/s, while Vs ranges from 4.0 to 4.4 km/s [85,120,125,133]. Anand et al. [133] observed that the eastern edge of the Assam Valley does not show decreased Vs, possibly due to the effects of the uncompensated Shillong Plateau and/or the Kopili fault. The seismic velocity distributions beneath the Shillong Plateau from [125] suggest that a stronger crust overlies a weaker, low-density mantle, with erosion and uplift potentially creating subcrustal voids that allow mantle fluids to rise and form an antiroot at the base of the plateau.

Anand et al. [124] identified a Vs increase at depths of 56–74 km, interpreted as a shallow Hales lithospheric mantle discontinuity, suggesting a hot upper mantle beneath the Shillong Plateau and eastern Assam Valley. In contrast, Chaudhury and Mitra [141] modeled the Hales discontinuity at greater depths: 90–106 km beneath the Assam Valley, with an 11–12% Vs increase, and 86–99 km beneath the Shillong Plateau, with a 6–10% Vs increase. Additionally, they identified a 2–9% Vs increase at shallower depths of 66–75 km, within the Shillong Plateau, which they interpreted as another intralithospheric discontinuity.

However, Devi et al. [137] identified the lithosphere–asthenosphere boundary (LAB) at a depth of 90 km beneath the Shillong Plateau, deepening to 135 km on either side, suggesting a lithospheric upwarp related to the plateau's uplift. They also observed that the lithosphere thickens further north, reaching ~180 km beneath the Eastern Himalaya. Kumar et al. [142] found a highly variable LAB depth across the region, with depths of 135 km beneath the Shillong Plateau, increasing to 160 km in the Bhutan Himalaya, and decreasing to ~75 km in the Central Assam Valley. Priestley and McKenzie [143], through surface wave tomography, revealed smoother lithospheric thickness variations, with the thickness ~160 km beneath the Shillong Plateau, increasing northeastward to 240 km in the Assam Syntaxis (Figure 10). In contrast, the global LITHO1.0 model [144] presents a patchy picture of the region, indicating a ~200 km thick lithosphere beneath the central Shillong Plateau, which decreases sharply to ~60 km within the Upper Assam Valley.

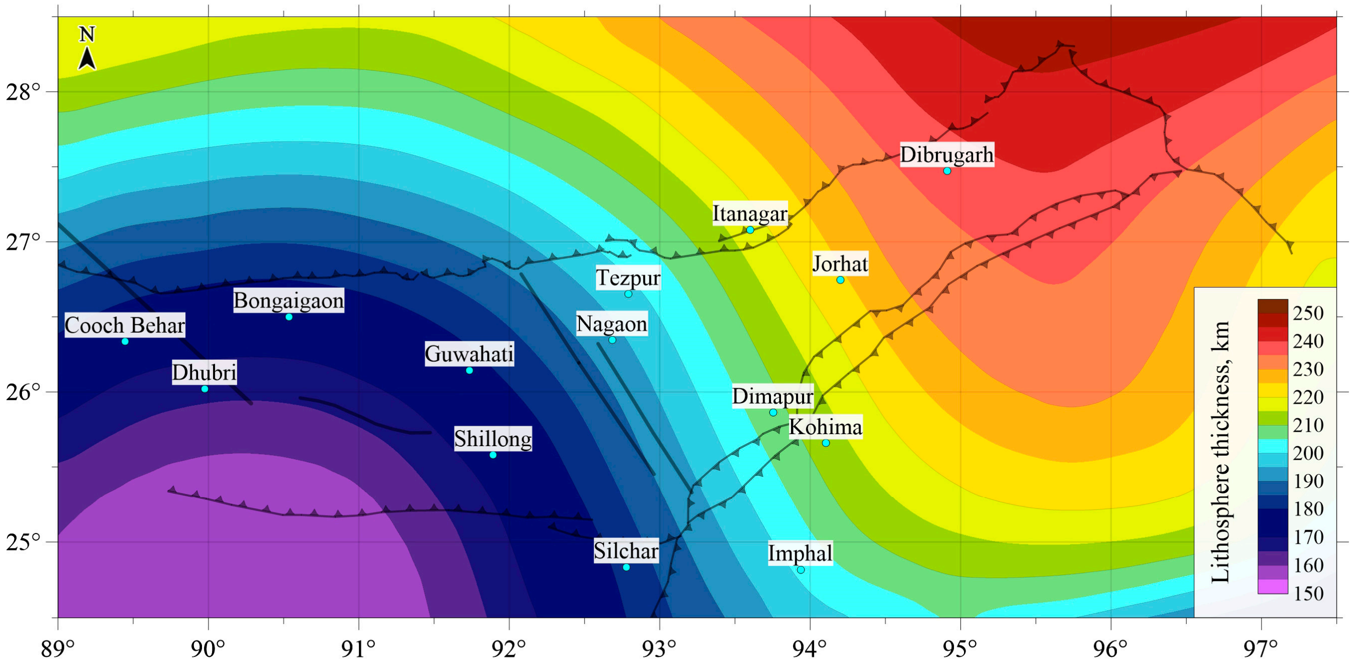


**Figure 10.** Depth to the LAB, adapted from Priestley and McKenzie [143].

Ramesh et al. [119] identified the 410 km and 660 km discontinuities in the region, revealing a uniform mantle transition zone from the Shillong Plateau to the Himalayan foothills, indicating no significant thermal anomalies. They also discovered the X-discontinuity at ~300 km, later confirmed across the Indian shield [145]. Saikia et al. [146] found the 410 km discontinuity uplifted by ~10 km beneath the Arunachal Himalaya and Upper Assam Valley and depressed in the Bengal Basin and Assam Syntaxis, with the 660 km discontinuity showing similar variations. Kumar et al. [147] suggested a major uplift near the Shillong Plateau, with average depths of 373 $\pm$ 4 km and 648 $\pm$ 6 km for the 410 km and 660 km discontinuities, respectively.

Dubey et al. [44] conducted P- and S-wave travel-time tomography study to image the subducting Indian plate down to 1000 km depth. Their findings indicate that the plate extends to the Bangong–Nujiang Suture Zone and steeply descends beyond 200 km below the Himalayan arc. A southward-plunging detached slab is traceable beyond 600 km, aligning with a model by Koulakov [148]. The study found no evidence of a southeast-deflecting Indian lithospheric slab beneath the Burmese arc and observed no gaps between the northward and eastward subducting plates, restricting the eastward escape of Tibetan lithospheric material between the Assam Syntaxis and the Sichuan Basin. They also identified anomalously high Vp and Vs within the Shillong Plateau and Assam Valley lithosphere.

*7.4. Seismic Anisotropy*

Seismic anisotropy estimates from shear wave splitting analysis offer insights into crustal and mantle flow as well as deformation patterns. Singh et al. [149] identified mantle anisotropy across the region, with E-W orientations in the central Assam Valley and Lesser Himalaya, NE-SW orientations near the Shillong Plateau, and N-S orientations in the Indo-Burma Ranges. Subsequent studies [150–153] mainly confirmed these findings, attributing the observed anisotropy to tectonic activity and the presence of active faults. Saikia et al. [154] and Kanaujia and Surve [155] expanded the analysis to include the Upper Assam Valley, Bengal Basin, and Assam Syntaxis. Mohanty et al. [156] estimated the central depth of seismic anisotropy to be ~100 km beneath the Shillong Plateau and ~150 km beneath the Assam Valley. In contrast, Kanaujia and Surve [155] reported greater depths of 160 km for the Eastern Himalaya, 180 km for the Bengal Basin, 240 km for the Indo-Burmese arc, and 320 km for the Shillong Plateau, noting the presence of two-layer anisotropy in the Eastern Himalaya, Shillong Plateau, and area southeast of the Dauki fault (Figure 11).

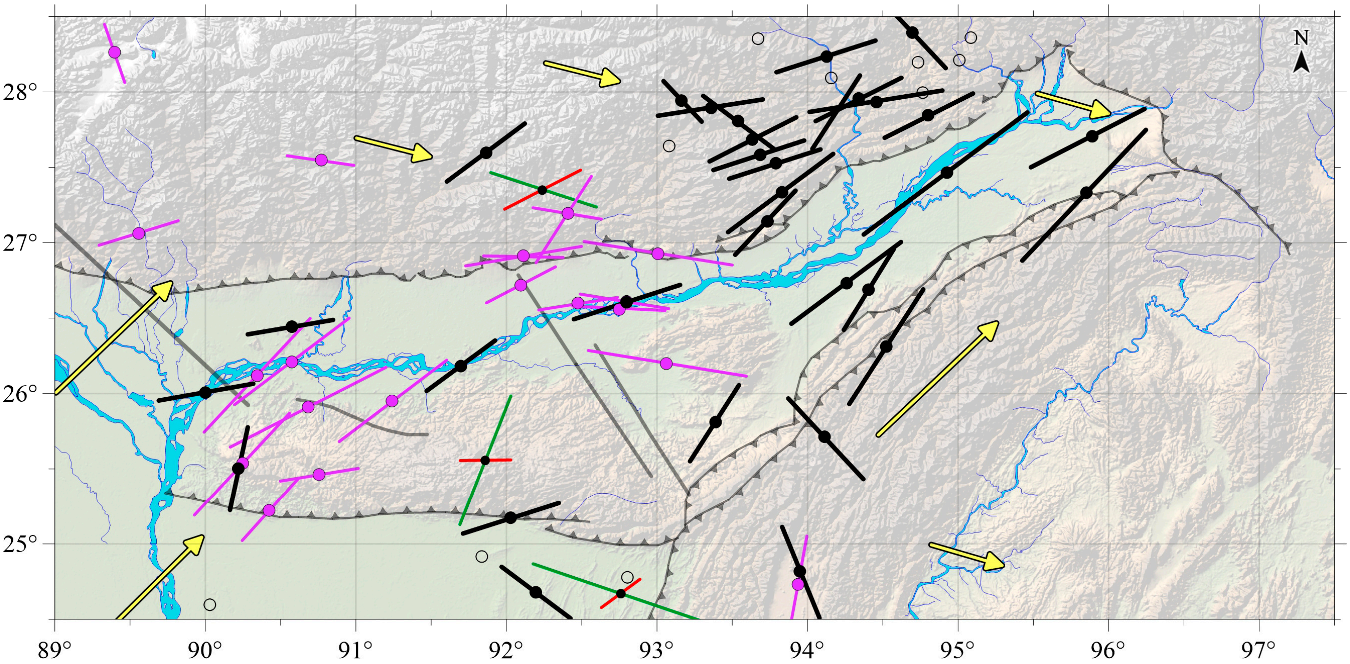


**Figure 11.** Shear wave splitting results, adapted from Kanaujia and Surve [155]. The red bars denote the fast polarization directions and delay times for the upper anisotropic layer, while the green bars indicate these parameters for the lower anisotropic layer. Estimates for single-layer anisotropy [155] are represented by black bars. Pink bars represent results from [149,157]. Hollow circles represent stations with absence of detectable splitting. Yellow arrows show the absolute plate motion directions within a no-net-rotation reference frame [158].

*7.5. Gravity and Magnetic Studies*

The crustal structure of the region has been studied through 2D Bouguer gravity data modeling along several regional profiles. Nayak et al. [88] examined a 350 km N-S profile across the Shillong Plateau, extending from the Bengal Basin to the Himalayan foothills. Their modeling, constrained by seismological data and structural assumptions, identified the south-dipping Oldham fault as the northern boundary of the plateau, with no conclusive evidence for the Brahmaputra fault. The study determined the Moho depth to be ~35 km beneath the Shillong Plateau, increasing to ~42 km beneath both the Bengal Basin and the Assam Valley. Ghosh et al. [159], through joint modeling of Euler deconvolution and 2.5D gravity data, suggested the presence of crustal intrusion and uplift beneath the Shillong Plateau. Their findings also indicated that the basement is uplifted near the Dauki fault and dips southward into the Bengal Basin.

Ravi Kumar et al. [43,160] conducted 2D gravity modeling, supported by seismic velocity models and 3D Euler deconvolution, along several regional profiles in NE India. They identified significant high-density mafic/ultramafic intrusive bodies beneath the Shillong–Mikir Plateaus and the Indo-Burma Ranges, likely associated with underplating processes. These intrusions are suggested to contribute to compressive stress and brittle deformation at shallow depths and to weaken the lower crust. The high-density materials beneath the Shillong–Mikir Plateau may be associated with a Kerguelen plume mantle source [34,161]. Additionally, the study identified aseismic zones north of the Shillong Plateau, south of the Mikir Hills, and along the NE-SW-trending Belt of Schuppen, which may indicate potential future seismic sources.

Gravity data from the region were also analyzed to locate thrusts and faults using techniques such as the source edge detection technique, tilt derivative, Cos(θ) analysis [162], and curvature interpretation [163]. This analysis uncovered several previously unmapped faults. The Brahmaputra Thrust, Dauki fault, Naga Thrust, Disang Thrust, and Kopili fault were found to be significant contributors to high seismicity and tectonic activity, causing uplift, subsidence, and anticlockwise rotation in the region.

Jiao et al. [164] inverted EMAG2 crustal magnetic anomaly data to construct a 3D magnetic model of the EHS area. By combining magnetic structures with rock susceptibilities, they delineated the crust's lithological composition and proposed a simplified two-stage evolution model. Their findings reveal a strong magnetic body near Namche Barwa and Gyala Peri Peaks, which may indicate a higher risk of significant earthquakes. The study suggests that material is being uplifted laterally from the deep crust, moving southeastward from the Tibetan Plateau's interior toward the surface.

Abramova et al. [165] analyzed the distribution of lithospheric magnetic anomalies (LMAs) across a wide region using satellite data collected over several years. Their results highlight the most intense positive anomaly in the Indo-Burma Ranges, which gradually decreases northward through the Assam Valley, reaching negative values in the Eastern Himalayas. This gradient zone may indicate the area where ferromagnetic materials in the lower crust are losing their magnetic properties due to mantle heating of the asthenosphere. Rawat et al. [166] developed an LMA model for the Indian subcontinent using seven years of magnetic data from Swarm satellites at an average altitude of 440 km. Their findings confirm that the Indo-Burma Ranges show the strongest positive LMA, while the Himalayas exhibit negative LMA.

### *7.6. Magnetotelluric Studies*

Magnetotelluric (MT) studies provide insights into the Earth's crust and upper mantle by imaging electrical conductivity from near-surface levels to depths of several hundred kilometers [167–169]. This technique can offer information on subsurface composition, thermal conditions, fluid content, and the geometry of active faults [168,170,171]. However, in NE India, the application of MT studies has been limited [172,173], which restricts a comprehensive understanding of the region's complex tectonic and geological features.

Gokarn et al. [86] conducted MT soundings along a north–south profile across the Shillong Plateau and Assam Valley. Their 2D inversion results [86,174], extending to depths of 50 km, identified the Dauki fault as an NE-SW thrust zone with a dip of ~30° (Figure 12). This zone was associated with the subduction of low-resistivity Bengal sediments and underlying oceanic crust. In the Assam Valley, a parallel thrust zone, corresponding to the Brahmaputra Fault, was interpreted as an intracratonic thrust within the Indian plate. The study suggests that the Shillong Plateau and adjacent sedimentary layers act as a supracrustal block, not directly involved in the subduction process. Additionally, the findings indicate that the NE Indian crust responds differently to compressive forces at various depths, influenced by rheological factors. The study conclusions are supported by subsequent passive seismic studies [122,123,130] and gravity modeling [43].

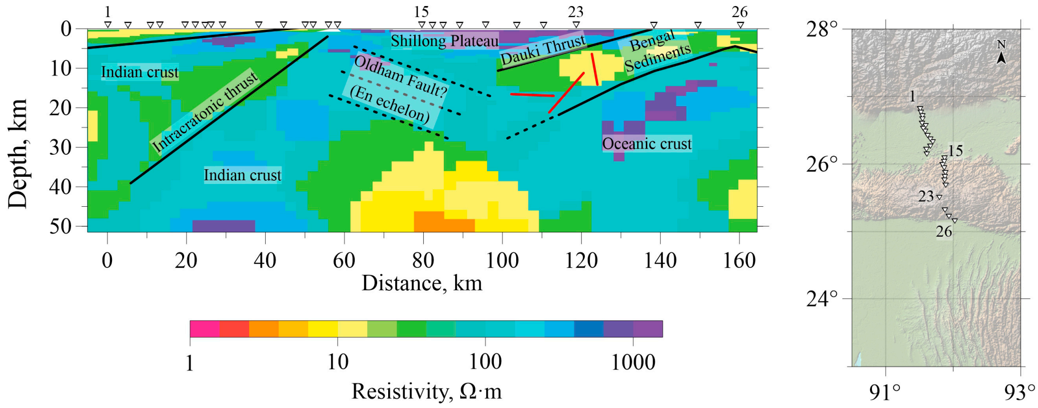


**Figure 12.** Geoelectric cross-section across the Assam Valley and Shillong Plateau, highlighting identified tectonic elements and rock types, adapted from Gokarn et al. [86]. The panel on the right shows the locations of MT sites, marked with triangles. Red lines indicate the location and dip directions of earthquake focal plane solutions [87].

In 2016–17, NEHU and GEMRC IPE RAS carried out MT measurements along the EHS-IND profile in the Central and Upper Assam Valley, supported by a joint DST/RFBR grant. Initial analysis by Varentsov et al. [175,176] revealed a deep crustal structure with high resistivity beneath the Upper Assam Valley, contrasting with highly conductive Tibetan blocks and a moderately conductive zone near the Shillong Plateau. The total sediment conductance was found to reach 400 S in the Upper Assam Valley, decreasing to less than 100 S westward (Figure 13). Distinct resistivity changes highlighted the Bomdila and Kopili fault zones. The presence of resistive crustal–mantle blocks suggests general geodynamic stability in the EHS zone, while resistivity variations may indicate areas with potential increased seismicity.

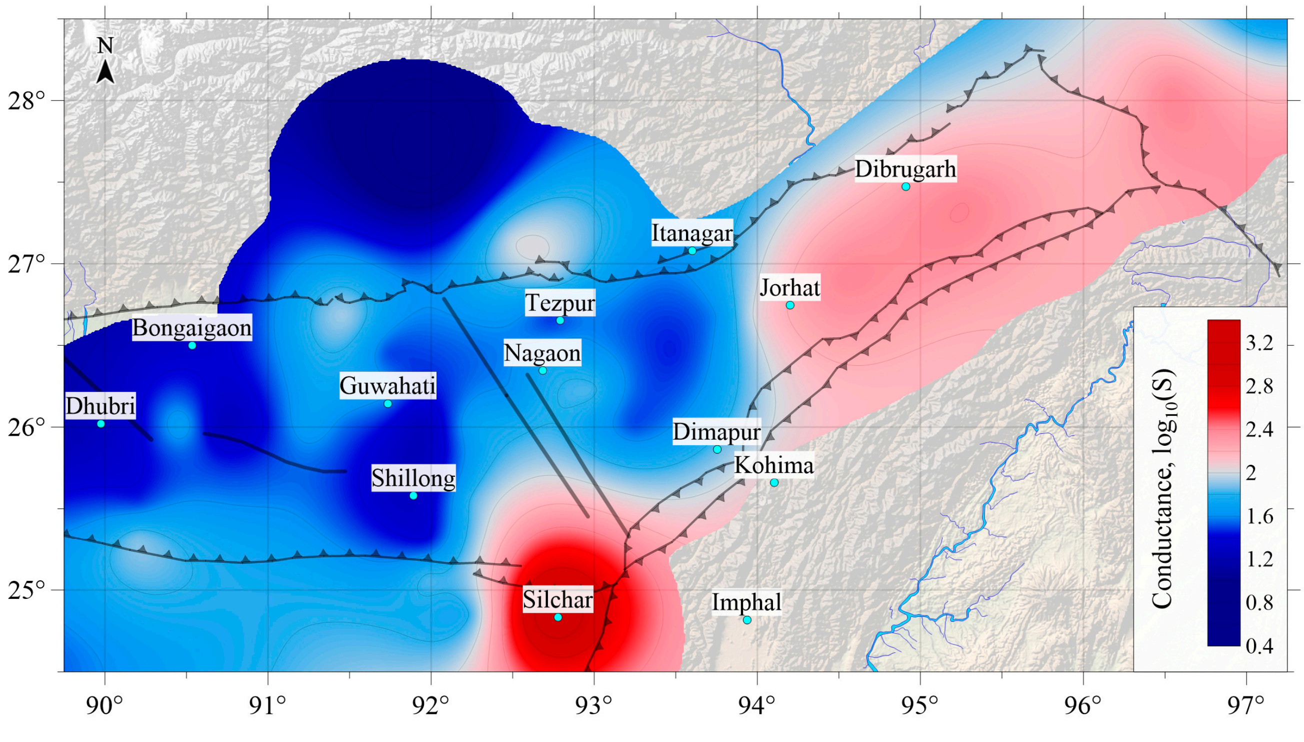


**Figure 13.** Total conductance of sediments (S, lg scale) estimated from MT data (determinant of the impedance tensor at 8 s), modified from Varentsov et al. [175].

Rawat and Luirei [55] conducted MT soundings along a profile in the Lohit Valley, within the Assam Syntaxis zone. Their 2D inversion of impedance (TM polarization) and tipper data identified a low-angle, northeast-dipping, intracrustal low-resistivity layer, interpreted as the Main Himalayan Thrust. They imaged the Lesser Himalaya and Lohit Plutonic Complex as resistive features, with a conductive zone between them indicating the Tidding Suture Zone. Major thrusts separating different tectonic zones across the profile aligned with the dipping conductive features. Further northeast, a 2D+ joint inversion of MT and magnetovariational data by Varentsov and Bai [177] revealed the continuation and deepening of the crustal anomalies, consistent with the subduction of the Indian plate.

## 8. Discussion

The northeastern region of India, characterized by its complex geodynamics, provides a unique environment for geophysical research. The studies reviewed in this manuscript, including seismic, gravity, magnetic, and magnetotelluric surveys, reveal a highly heterogeneous subsurface structure shaped by active tectonic processes. Despite many findings being consistent, notable discrepancies challenge a unified understanding of the region's geodynamic evolution, seismic sources, and earthquake risk. Several gaps remain in our understanding, including the following:

- Geophysical studies have identified significant variations in sedimentary thickness across the Assam Valley, ranging from 0.5 to 6.5 km, with thickness increasing from southwest to northeast. However, research has primarily focused on the Upper Assam Valley, south of the Brahmaputra River. Further detailed exploration in the Eastern Himalayan and Mishmi foothills, Naga–Schuppen belt, and southward along the Assam–Arakan Fold Belt could offer new insights into hydrocarbon and mineral exploration potential. Additionally, refining shallow structural details could improve earthquake localization, enhance ground motion simulations, and better assess potential damage from impending large earthquakes.
- The relative seismic quietness of the Upper Assam Basin raises questions. The concept of the "Assam Gap", which suggests a zone of high accumulated stress that could lead to a future great earthquake, requires further validation through deep geophysical and paleoseismological studies.
- Limited research has been conducted on the 1897 Shillong Plateau earthquake area and the hidden Oldham Fault, whose location and geometry remain debated. Further investigation is needed to clarify the northern boundary of the Shillong Plateau, which may be defined by the Brahmaputra or Oldham Fault. Understanding these features could provide insights into the uplift mechanisms of the Shillong Plateau. Additionally, comprehensive studies of the Dauki fault, the southern boundary of the Shillong Plateau, are necessary to understand its kinematics, east–west variations, and the potential underthrusting of Bengal Basin sediments beneath the plateau.
- The Kopili fault, one of the most active and hazardous zones within the Assam Valley, requires detailed study of its deep roots and geometry. Additionally, the differing interpretations of the extent and position of the Bomdila Fault across various studies highlight the need for further investigation.
- Studies on crustal and upper mantle velocity structures are essential for enhancing our understanding of tectonic evolution and seismic activity. Passive seismological studies indicate a thinner crust beneath the Shillong Plateau and Mikir Hills (33–37 km), with an increase in thickness in the Assam Valley (35–42 km) and further thickening in the Himalaya and Assam Syntaxis (40–43 km) and the Indo-Burma Ranges (42–50 km). However, the geometry and spatial extent of localized crustal anomalies, identified by variations in seismic velocities, require further study. Additionally, estimates of

mantle seismic discontinuities, including the depth of the lithosphere–asthenosphere boundary and its significant uplift beneath the Shillong Plateau, show varying results. Despite a robust seismic network in NE India, increased station coverage may be necessary to address the region's complexity.

- Recent gravity studies in the region have provided promising results. Further analysis of high-precision gravity and magnetic surveys at a scale of 1:50,000, currently being conducted by the Geological Survey of India, will provide deeper insights into the region's subsurface structure.
- Many of the identified gaps could be addressed through large-scale broadband and long-period MT studies, which are currently limited in the region. By providing detailed electrical resistivity models across a wide range of depths, these studies can offer valuable insights into subsurface lithology, fluid content, thermal state, and deep fault geometry.

## 9. Conclusions

NE India is one of the most seismically active regions in the world, having experienced major earthquakes in recent history. Understanding its subsurface configuration is essential for assessing seismic hazards, mitigating risks, and guiding resource exploration. This manuscript reviews the geological and tectonic settings of the region and summarizes recent advances in geophysical studies, with a particular focus on the Assam Valley and surrounding areas. Through this review, several critical knowledge gaps have been identified in the existing literature. Despite substantial research efforts, current geophysical coverage remains insufficient to capture the full complexity of the region. Addressing these gaps will require further studies, both region-wide and focused on high-priority areas. This review provides a foundation for future research, aimed at improving seismic hazard assessments, refining resource exploration strategies, and supporting sustainable development in the region.

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## References

1. Verma, M.; Bansal, B.K. Active Fault Research in India: Achievements and Future Perspective. *Geomat. Nat. Hazards Risk* **2016**, *7*, 65–84. [CrossRef]
2. Pandey, A.K.; Chingtham, P.; Roy, P.N.S. Homogeneous Earthquake Catalogue for Northeast Region of India Using Robust Statistical Approaches. *Geomat. Nat. Hazards Risk* **2017**, *8*, 1477–1491. [CrossRef]
3. Phukan, A.; Mohanty, D.D. Seismic Hazard Estimation and Medium-Term Earthquake Precursor Analysis of North East India: An Assessment on Large Earthquake Scenario. *All Earth* **2023**, *35*, 46–64. [CrossRef]
4. Nandy, D.R. *Geodynamics of North Eastern India and the Adjoining Region*; ACB. Publ.: Kolkata, India, 2001.
5. Kayal, J. Seismicity of Northeast India and Surroundings—Development over the Past 100 Years. *J. Geophys.* **1998**, *19*, 9–34.

6. Subedi, S.; Hetényi, G. Precise Locating of the Great 1897 Shillong Plateau Earthquake Using Teleseismic and Regional Seismic Phase Data. *Seism. Rec.* **2021**, *1*, 135–144. [CrossRef]
7. Coudurier-Curveur, A.; Tapponnier, P.; Okal, E.; Van Der Woerd, J.; Kali, E.; Choudhury, S.; Baruah, S.; Etchebes, M.; Karakaş, Ç. A Composite Rupture Model for the Great 1950 Assam Earthquake across the Cusp of the East Himalayan Syntaxis. *Earth Planet. Sci. Lett.* **2020**, *531*, 115928. [CrossRef]
8. Kayal, J.R.; Arefiev, S.S.; Baruah, S.; Hazarika, D.; Gogoi, N.; Gautam, J.L.; Baruah, S.; Dorbath, C.; Tatevossian, R. Large and Great Earthquakes in the Shillong Plateau-Assam Valley Area of Northeast India Region: Pop-up and Transverse Tectonics. *Tectonophysics* **2012**, *532–535*, 186–192. [CrossRef]
9. Shukla, N.; Hazarika, D.; Kundu, A.; Mukhopadhyay, S. Spatial Variations of Crustal Thickness and Poisson's Ratio in the Northeastern Region of India Based on Receiver Function Analysis. *Geol. J.* **2022**, *57*, 5083–5096. [CrossRef]
10. *CED 39 IS 1893 (Part 1): 2016*; Criteria for Earthquake Resistant Design of Structures: Part 1 General Provisions and Buildings (Sixth Revision). Bureau of Indian Standards: New Delhi, India, 2021.
11. Bhattacharya, B.; Conway, C.; Solomatine, D.; Masih, I.; Craven, J.; Mazumder, L.C.; Mazzoleni, M.; Ugay, R.; Van Andel, S.J.; Shrestha, S. Hydrological and Erosion Modelling of the Brahmaputra Basin Using Global Datasets. In Proceedings of the HIC 2018 13th International Conference on Hydroinformatics, Palermo, Italy, 7–13 July 2018; Volume 3, pp. 245–251.
12. Saikia, S.; Chopra, S.; Baruah, S.; Singh, U.K. Shallow Sedimentary Structure of the Brahmaputra Valley Constraint from Receiver Functions Analysis. *Pure Appl. Geophys.* **2017**, *174*, 229–247. [CrossRef]
13. Khattri, K.; Wyss, M.; Gaur, V.K.; Saha, S.N.; Bansal, V.K. Local Seismic Activity in the Region of the Assam Gap, Northeast India. *Bull. Seismol. Soc. Am.* **1983**, *73*, 459–469.
14. Khattri, K.; Wyss, M. Precursory Variation of Seismicity Rate in the Assam Area, India. *Geology* **1978**, *6*, 685–688. [CrossRef]
15. Kayal, J.R.; De, R. Microseismicity and Tectonics in Northeast India. *Bull. Seismol. Soc. Am.* **1991**, *81*, 131–138. [CrossRef]
16. Mukhopadhyay, M. Seismotectonics of Transverse Lineaments in the Eastern Himalaya and Its Foredeep. *Tectonophysics* **1984**, *109*, 227–240. [CrossRef]
17. Rajendran, K.; Rajendran, C.P. Revisiting the Earthquake Sources in the Himalaya: Perspectives on Past Seismicity. *Tectonophysics* **2011**, *504*, 75–88. [CrossRef]
18. Barman, S. The Seismicity Of North East India—Its Strain Release, Accumulation And Potentiality And Seismic Indifference In The Assam Gap: An Analysis. *Int. J. Aquat. Sci.* **2021**, *12*, 25–33.
19. Srivastava, H.N.; Verma, M.; Bansal, B.K.; Sutar, A.K. Discriminatory Characteristics of Seismic Gaps in Himalaya. *Geomat. Nat. Hazards Risk* **2015**, *6*, 224–242. [CrossRef]
20. GEBCO Bathymetric Compilation Group 2024. *The GEBCO_2024 Grid—A Continuous Terrain Model of the Global Oceans and Land*; NERC EDS British Oceanographic Data Centre NOC: Southampton, UK, 2024. [CrossRef]
21. GSI Bhukosh Rivers. Available online: https://bhukosh.gsi.gov.in (accessed on 13 June 2024).
22. Sahoo, M.; Gogoi, K.D. Paleocene to Holocenestructure, Stratigraphic Development and Hydrocarbon Accumulation in Upper Assam Foreland Basin, India. *Assoc. Petrol. Geol. Bull.* **2010**, *6*, 633–646.
23. Bezbaruah, D.; Goswami, T.K.; Sarmah, R.K. The Upper Assam Basin, Its Evolution, and Modification: A Review. In *Handbook of Petroleum Geoscience*; Mukherjee, S., Dasgupta, S., Majumdar, C., Mandal, S., Dasgupta, T., Eds.; Wiley: Hoboken, NJ, USA, 2022; pp. 280–299, ISBN 978-1-119-68003-1.
24. Borgohain, R.; Sarmah, R.K. Lithostratigraphy of the Paleogene Shelf Sediments in Assam and Meghalaya—A Review. *Indian Streams Res. J.* **2012**, *2*, 1–4.
25. Choudhuri, M.; Routray, P.; Jana, B.; Mathur, S. Timing the Mikir Hill Uplift in Assam Basin: Record of Stress Propagation along the Eastern Margin of the Indian Plate. *J. Asian Earth Sci. X* **2023**, *9*, 100137. [CrossRef]
26. Das Gupta, A.B.; Biswas, A.K. *Geology of Assam*, 1st ed.; Geological Society of India: Bangalore, India, 2000; ISBN 978-81-85867-44-1.
27. Deshpande, S.V.; Goel, S.M.; Bhandari, A.; Barua, R.M.; Deshpande, J.S.; Kumar, A.; Rana, K.S.; Chitrao, A.M.; Giridhar, M.; Chaudhuri, D.; et al. *Lithostratigraphy of Indian Petroliferous Basins*; Document X-Assam-Arakan Basins. Unpubld. ONGC Document; KDMIPE: Dehradun, India, 1993.
28. Evans, P. The Tectonic Framework of Assam. *J. Geol. Soc. India* **1964**, *5*, 80–96. [CrossRef]
29. Evans, P. Tertiary Succession in Assam. *Trans. Min. Geol. Inst. India* **1932**, *5*, 155–260.
30. GSI. *Geology and Mineral Resources of Assam*, 3rd ed.; Miscellaneous Publication; Geological Survey of India: Kolkata, India, 2019; Volume 2.
31. Kumar, P.C.; Kumar, J.; Sain, K. Cenozoic Tectonic Subsidence in the Upper Assam Basin, NE India. *Geosyst. Geoenviron.* **2024**, *3*, 100223. [CrossRef]
32. Narayan, S.; Singh, R.; Mohan, A.; Vivek, K.; Acharya, P.; Pal, S.K. Delineation of Thin and Discrete Sand Reservoir Facies from Shale-Dominated Kopili Formation (Middle to Late Eocene) Using the Post-Stack Seismic Inversion and Neural Network Algorithm: A Case Study from Assam Basin, India. *J. Earth Syst. Sci.* **2023**, *132*, 81. [CrossRef]

33. Srivastava, R.K.; Guarino, V.; Melluso, L. Early Cretaceous Ultramafic-Alkaline-Carbonatite Magmatism in the Shillong Plateau-Mikir Hills, Northeastern India—A Synthesis. *Mineral. Petrol.* **2023**, *117*, 447–466. [CrossRef]
34. Saha, A.; Ganguly, S.; Ray, J.; Koeberl, C.; Thöni, M.; Sarbajna, C.; Sawant, S.S. Petrogenetic Evolution of Cretaceous Samchampi-Samteran Alkaline Complex, Mikir Hills, Northeastern India: Implications on Multiple Melting Events of Heterogeneous Plume and Metasomatized Sub-Continental Lithospheric Mantle. *Gondwana Res.* **2017**, *48*, 237–256. [CrossRef]
35. Vadlamani, R.; Wu, F.-Y.; Ji, W.-Q. Detrital Zircon U–Pb Age and Hf Isotopic Composition from Foreland Sediments of the Assam Basin, NE India: Constraints on Sediment Provenance and Tectonics of the Eastern Himalaya. *J. Asian Earth Sci.* **2015**, *111*, 254–267. [CrossRef]
36. Wu, X.; Hu, J.; Chen, L.; Liu, L.; Liu, L. Paleogene India-Eurasia Collision Constrained by Observed Plate Rotation. *Nat. Commun.* **2023**, *14*, 7272. [CrossRef] [PubMed]
37. Mohan, M.; Pandey, J. Early Paleogene Eco-Stratigraphy of Upper Assam. *Bull. Indian Geol. Assoc.* **1973**, *6*, 47–62.
38. Bezbaruah, D.; Mujamil, S. Deposition History of Coal Bearing Tikak Parbat Formation of Barail Group in a Part of the Belt of Schuppen, Northeast India. *South East Asian J. Sediment. Basin Res.* **2013**, *1*, 50–66.
39. Singh, A.P.; Mishra, O.P.; Singh, O.P. Seismic Evidence of Pop-up Tectonics beneath the Shillong Plateau Area of Northeast India. *Sci. Rep.* **2022**, *12*, 14135. [CrossRef] [PubMed]
40. Uddin, A.; Lundberg, N. A Paleo-Brahmaputra? Subsurface Lithofacies Analysis of Miocene Deltaic Sediments in the Himalayan–Bengal System, Bangladesh. *Sediment. Geol.* **1999**, *123*, 239–254. [CrossRef]
41. Mitra, S.; Priestley, K.; Bhattacharyya, A.K.; Gaur, V.K. Crustal Structure and Earthquake Focal Depths beneath Northeastern India and Southern Tibet. *Geophys. J. Int.* **2005**, *160*, 227–248. [CrossRef]
42. Raoof, J.; Mukhopadhyay, S.; Koulakov, I.; Kayal, J.R. 3-D Seismic Tomography of the Lithosphere and Its Geodynamic Implications beneath the Northeast India Region. *Tectonics* **2017**, *36*, 962–980. [CrossRef]
43. Ravi Kumar, C.A.; Selin Raj, A.; Pathak, B.; Maiti, S.; Naganjaneyulu, K. High Density Crustal Intrusive Bodies beneath Shillong Plateau and Indo Burmese Range of Northeast India Revealed by Gravity Modeling and Earthquake Data. *Phys. Earth Planet. Inter.* **2020**, *307*, 106555. [CrossRef]
44. Dubey, A.K.; Singh, A.; Kumar, M.R.; Jana, N.; Sarkar, S.; Saikia, D.; Singh, C. Tomographic Imaging of the Plate Geometry Beneath the Arunachal Himalaya and Burmese Subduction Zones. *Geophys. Res. Lett.* **2022**, *49*, e2022GL098331. [CrossRef]
45. Earnest, A.; Sunilkumar, T.C.; Silpa, K. Sinking Slab Stress and Seismo-Tectonics of the Indo-Burmese Arc: A Reappraisal. *Tectonics* **2021**, *40*, e2021TC006827. [CrossRef]
46. Wang, C.; Mooney, W.D.; Zhu, L.; Wang, X.; Lou, H.; You, H.; Cao, Z.; Chang, L.; Yao, Z. Deep Structure of the Eastern Himalayan Collision Zone: Evidence for Underthrusting and Delamination in the Postcollisional Stage. *Tectonics* **2019**, *38*, 3614–3628. [CrossRef]
47. Ding, L.; Zhong, D.; Yin, A.; Kapp, P.; Harrison, T.M. Cenozoic Structural and Metamorphic Evolution of the Eastern Himalayan Syntaxis (Namche Barwa). *Earth Planet. Sci. Lett.* **2001**, *192*, 423–438. [CrossRef]
48. Zhang, L.; Liang, S.; Yang, X.; Dai, C. The Migration of the Crustal Deformation Peak Area in the Eastern Himalayan Syntaxis Inferred from Present-Day Crustal Deformation and Morpho-Tectonic Markers. *Geod. Geodyn.* **2021**, *12*, 165–174. [CrossRef]
49. Sharma, M.; Malik, H. Probabilistic Seismic Hazard Analysis and Estimation of Spectral Strong Ground Motion on Bed Rock in North East India. In Proceedings of the 4th International Conference on Earthquake Engineering, Taipei, Taiwan, 12–13 October 2006.
50. Sil, A.; Sitharam, T.G.; Kolathayar, S. Probabilistic Seismic Hazard Analysis of Tripura and Mizoram States. *Nat. Hazards* **2013**, *68*, 1089–1108. [CrossRef]
51. Das, R.; Sharma, M.L.; Wason, H.R. Probabilistic Seismic Hazard Assessment for Northeast India Region. *Pure Appl. Geophys.* **2016**, *173*, 2653–2670. [CrossRef]
52. Baro, O.; Kumar, A.; Ismail-Zadeh, A. Seismic Hazard Assessment of the Shillong Plateau, India. *Geomat. Nat. Hazards Risk* **2018**, *9*, 841–861. [CrossRef]
53. Angelier, J.; Baruah, S. Seismotectonics in Northeast India: A Stress Analysis of Focal Mechanism Solutions of Earthquakes and Its Kinematic Implications. *Geophys. J. Int.* **2009**, *178*, 303–326. [CrossRef]
54. Jade, S.; Shrungeshwara, T.S.; Kumar, K.; Choudhury, P.; Dumka, R.K.; Bhu, H. India Plate Angular Velocity and Contemporary Deformation Rates from Continuous GPS Measurements from 1996 to 2015. *Sci. Rep.* **2017**, *7*, 11439. [CrossRef] [PubMed]
55. Rawat, G.; Luirei, K. Deep Crustal Resistivity Structure of the Lohit Valley in the Eastern Himalayan Syntaxial Region. *Geol. J.* **2022**, *57*, 4920–4928. [CrossRef]
56. Dasgupta, S.; Mukhopadhyay, B.; Mukhopadhyay, M.; Pande, P. Geo- and Seismo- Tectonics of Eastern Himalaya: Exploring Earthquake Source Zones from Foredeep to Tibetan Hinterland. *Phys. Chem. Earth Parts A/B/C* **2021**, *123*, 103013. [CrossRef]
57. Bhadran, A.; Duarah, B.P.; Girishbai, D.; Atif Raza, M.; Mero, A.; Lahon, S.; Achu, A.L.; Gopinath, G. Soft Sediment Deformation Structures from the Brahmaputra Basin: A Window to the Eastern Himalayan Paleoseismicity and Tectonics. *J. Asian Earth Sci.* **2024**, *259*, 105894. [CrossRef]

58. Kothyari, G.C.; Malik, K.; Dumka, R.K.; Naik, S.P.; Biswas, R.; Taloor, A.K.; Luirei, K.; Joshi, N.; Kandregula, R.S. Identification of Active Deformation Zone Associated with the 28th April 2021 Assam Earthquake (Mw 6.4) Using the PSInSAR Time Series. *J. Appl. Geophys.* **2022**, *206*, 104811. [CrossRef]
59. England, P.; Bilham, R. The Shillong Plateau and the Great 1897 Assam Earthquake. *Tectonics* **2015**, *34*, 1792–1812. [CrossRef]
60. Goswami, T.K.; Gogoi, M.; Mahanta, B.N.; Mukherjee, S.; Saikia, H.; Shaikh, M.A.; Kalita, P.; Baral, U.; Sarmah, R.K. Brittle Tectonics in the Western Arunachal Himalayan Frontal Fold Belt, Northeast India: Change in Stress Regime from Pre-collisional Extension to Collisional Compression. *Geol. J.* **2022**, *57*, 5019–5038. [CrossRef]
61. Mallick, R.; Lindsey, E.O.; Feng, L.; Hubbard, J.; Banerjee, P.; Hill, E.M. Active Convergence of the India-Burma-Sunda Plates Revealed by a New Continuous GPS Network. *J. Geophys. Res. Solid Earth* **2019**, *124*, 3155–3171. [CrossRef]
62. Paul, J.; Bürgmann, R.; Gaur, V.K.; Bilham, R.; Larson, K.M.; Ananda, M.B.; Jade, S.; Mukal, M.; Anupama, T.S.; Satyal, G.; et al. The Motion and Active Deformation of India. *Geophys. Res. Lett.* **2001**, *28*, 647–650. [CrossRef]
63. Vernant, P.; Bilham, R.; Szeliga, W.; Drupka, D.; Kalita, S.; Bhattacharyya, A.K.; Gaur, V.K.; Pelgay, P.; Cattin, R.; Berthet, T. Clockwise Rotation of the Brahmaputra Valley Relative to India: Tectonic Convergence in the Eastern Himalaya, Naga Hills, and Shillong Plateau. *J. Geophys. Res. Solid Earth* **2014**, *119*, 6558–6571. [CrossRef]
64. Barman, P.; Jade, S.; Shrungeshwara, T.S.; Kumar, A.; Bhattacharyya, S.; Ray, J.D.; Jagannathan, S.; Jamir, W.M. Crustal Deformation Rates in Assam Valley, Shillong Plateau, Eastern Himalaya, and Indo-Burmese Region from 11 Years (2002–2013) of GPS Measurements. *Int. J. Earth Sci.* **2017**, *106*, 2025–2038. [CrossRef]
65. Jade, S.; Mukul, M.; Bhattacharyya, A.K.; Vijayan, M.S.M.; Jaganathan, S.; Kumar, A.; Tiwari, R.P.; Kumar, A.; Kalita, S.; Sahu, S.C.; et al. Estimates of Interseismic Deformation in Northeast India from GPS Measurements. *Earth Planet. Sci. Lett.* **2007**, *263*, 221–234. [CrossRef]
66. Mahesh, P.; Catherine, J.K.; Gahalaut, V.K.; Kundu, B.; Ambikapathy, A.; Bansal, A.; Premkishore, L.; Narsaiah, M.; Ghavri, S.; Chadha, R.K.; et al. Rigid Indian Plate: Constraints from GPS Measurements. *Gondwana Res.* **2012**, *22*, 1068–1072. [CrossRef]
67. USGS ANSS Comprehensive Earthquake Catalog (ComCat). Available online: https://earthquake.usgs.gov/earthquakes/search/ (accessed on 1 August 2024).
68. Albini, P.; Musson, R.M.W.; Rovida, A.; Locati, M.; Gomez Capera, A.A.; Viganò, D. The Global Earthquake History. *Earthq. Spectra* **2014**, *30*, 607–624. [CrossRef]
69. Joshi, M.; Naik, S.P.; Mohanty, A.; Bhadran, A.; Girishbai, D.; Ghosh, S. First Hand Observations from the April 28, 2021 Sonitpur (MW 6.4) Earthquake, Assam, India: Possible Mechanism Involved in the Occurrence of Widespread Ground Effects. *Geosci. J.* **2023**, *27*, 225–239. [CrossRef]
70. Lakshmi, B.V.; Baba, M.M.; Gawali, P.B. Investigation of Past Earthquakes in the Kopili Fault Zone, NE India: New Evidence of Paleoliquefaction. *Nat. Hazards* **2023**, *119*, 2113–2131. [CrossRef]
71. Rakshit, K.; Rakshit, R. Study of 28th April, 2021 Mw 6.0 Assam Earthquake in a Part of Eastern Himalayan Foreland Region, Northeast India. *Environ. Earth Sci.* **2022**, *81*, 368. [CrossRef]
72. Sharma, V.; Biswas, R. Seismic Hazard Assessment and Source Zone Delineation in Northeast India: A Case Study of the Kopili Fault Region and Its Vicinity. *Indian Geotech. J.* **2024**, *54*, 598–626. [CrossRef]
73. Kayal, J.R.; Arefiev, S.S.; Baruah, S.; Tatevossian, R.; Gogoi, N.; Sanoujam, M.; Gautam, J.L.; Hazarika, D.; Borah, D. The 2009 Bhutan and Assam Felt Earthquakes (Mw 6.3 and 5.1) at the Kopili Fault in the Northeast Himalaya Region. *Geomat. Nat. Hazards Risk* **2010**, *1*, 273–281. [CrossRef]
74. Sharma, S.; Sarma, J.; Baruah, S. Dynamics of Mikir Hills Plateau and Its Vicinity: Inferences on Kopili and Bomdila Faults in Northeastern India through Seismotectonics, Gravity and Magnetic Anomalies. *Ann. Geophys.* **2018**, *61*, 338. [CrossRef]
75. Bora, N.; Büyükakpınar, P.; Das, S. 3D Structural Modelling of the Kopili Fault Zone in North-East India: Seismotectonic Analysis Utilising Focal Mechanism Solutions of Small-to-Moderate Earthquakes. *J. Asian Earth Sci.* **2024**, *276*, 106348. [CrossRef]
76. Barman, P.; Ray, J.D.; Kumar, A.; Chowdhury, J.D.; Mahanta, K. Estimation of Present-Day Inter-Seismic Deformation in Kopili Fault Zone of North-East India Using GPS Measurements. *Geomat. Nat. Hazards Risk* **2016**, *7*, 586–599. [CrossRef]
77. Sutar, A.K.; Verma, M.; Pandey, A.P.; Bansal, B.K.; Rajendra Prasad, P.; Rama Rao, P.; Sharma, B. Assessment of Maximum Earthquake Potential of the Kopili Fault Zone in Northeast India and Strong Ground Motion Simulation. *J. Asian Earth Sci.* **2017**, *147*, 439–451. [CrossRef]
78. Goswami, T.K.; Kalita, P.; Mukherjee, S.; Mahanta, B.N.; Sarmah, R.K.; Laishram, R.; Saikia, H.; Gogoi, M.; Machahary, R.; Oza, B. Basement Cross-Strike Bomdila Fault beneath Arunachal Himalaya: Deformation along Curved Thrust Traces, Seismicity, and Implications in Hydrocarbon Prospect of the Gondwana Sediments. *Geol. J.* **2022**, *57*, 4974–4999. [CrossRef]
79. Sarma, J.N.; Sharma, S. Neotectonic Activity of the Bomdila Fault in Northeastern India from Geomorphological Evidences Using Remote Sensing and GIS. *J. Earth Syst. Sci.* **2018**, *127*, 113. [CrossRef]
80. Walia, D.; Chaudhary, S. Geology and Mineral Resources of Meghalaya. In *Geo-Resources*; Scientific Publishers: New Delhi, India, 2014; ISBN 978-81-7233-895-4.

81. GSI. *Geology and Mineral Resources of Meghalaya*, 3rd ed.; Miscellaneous Publication; Geological Survey of India: Kolkata, India, 2023; Volume 2.
82. Siangshai, D.M.; Walia, D.; Saxena, A.; Lyngdoh, A.C. Assessing the Seismicity of Shillong Plateau Using "b Value". *Int. J. Earth Sci. Geophys.* **2021**, *7*, 51. [CrossRef]
83. Lyngdoh, A.C. Study of Seismicity and Active Tectonics in the South Eastern Part of the Shillong Plateau. Ph.D. Thesis, North-Eastern Hill University, Shillong, India, 2013.
84. Baro, O.; Kumar, A. Seismic Source Characterization for the Shillong Plateau in Northeast India. *J. Seismol.* **2017**, *21*, 1229–1249. [CrossRef]
85. Mitra, S.; Priestley, K.F.; Borah, K.; Gaur, V.K. Crustal Structure and Evolution of the Eastern Himalayan Plate Boundary System, Northeast India. *J. Geophys. Res. Solid Earth* **2018**, *123*, 621–640. [CrossRef]
86. Gokarn, S.G.; Gupta, G.; Walia, D.; Sanabam, S.S.; Hazarika, N. Deep Geoelectric Structure over the Lower Brahmaputra Valley and Shillong Plateau, NE India Using Magnetotellurics. *Geophys. J. Int.* **2008**, *173*, 92–104. [CrossRef]
87. Kayal, J.R.; Arefiev, S.S.; Barua, S.; Hazarika, D.; Gogoi, N.; Kumar, A.; Chowdhury, S.N.; Kalita, S. Shillong Plateau Earthquakes in Northeast India Region: Complex Tectonic Model. *Curr. Sci.* **2006**, *91*, 109–114.
88. Nayak, G.K.; Rao, V.K.; Rambabu, H.V.; Kayal, J.R. Pop-up Tectonics of the Shillong Plateau in the Great 1897 Earthquake (Ms 8.7): Insights from the Gravity in Conjunction with the Recent Seismological Results. *Tectonics* **2008**, *27*, TC1018. [CrossRef]
89. Rajendran, C.P.; Rajendran, K.; Duarah, B.P.; Baruah, S.; Earnest, A. Interpreting the Style of Faulting and Paleoseismicity Associated with the 1897 Shillong, Northeast India, Earthquake: Implications for Regional Tectonism. *Tectonics* **2004**, *23*, TC4009. [CrossRef]
90. Sukhija, B.S.; Reddy, D.V.; Kumar, D.; Nagabhushanam, P. Comment on "Interpreting the Style of Faulting and Paleoseismicity Associated with the 1897 Shillong, Northeast India, Earthquake: Implications for Regional Tectonism" by C. P. Rajendran et al. *Tectonics* **2006**, *25*, TC2009. [CrossRef]
91. Hazarika, D.; Kundu, A.; Ghosh, P. Seismotectonic Scenario of the Indenting Northeast Corner of the Indian Plate in the Tidding-Tuting Suture Zone of the Eastern Himalayan Syntaxis. *Tectonophysics* **2022**, *824*, 229197. [CrossRef]
92. Saikia, A. Imperialism, Geology and Petroleum: History of Oil in Colonial Assam. *Econ. Political Wkly.* **2011**, *46*, 48–55.
93. Visvanath, S.N. *A Hundred Years of Oil a Narrative Account of the Search for Oil in India*; Vikas Pub. House: Mumbai, India, 1990.
94. Kent, W.N.; Dasgupta, U. Structural Evolution in Response to Fold and Thrust Belt Tectonics in Northern Assam. A Key to Hydrocarbon Exploration in the Jaipur Anticline Area. *Mar. Pet. Geol.* **2004**, *21*, 785–803. [CrossRef]
95. Gogoi, T.; Chatterjee, R. Estimation of Petrophysical Parameters Using Seismic Inversion and Neural Network Modeling in Upper Assam Basin, India. *Geosci. Front.* **2019**, *10*, 1113–1124. [CrossRef]
96. Majumdar, D.; Devi, A. Oilfield Geothermal Resources of the Upper Assam Petroliferous Basin, NE India. *Energy Geosci.* **2021**, *2*, 246–253. [CrossRef]
97. DGH Assam-Arakan Basin | Directorate General of Hydrocarbons. Available online: https://dghindia.gov.in/index.php/page?pageId=67&name=Indian%2520Geology (accessed on 6 August 2024).
98. Wandrey, C.J. *Sylhet-Kopili/Barail-Tipam Composite Total Petroleum System, Assam Geologic Province, India*; U.S. Geological Survey Bulletin 2208-D; U.S. Department of the Interior: Washington, DC, USA; U.S. Geological Survey: Reston, VA, USA, 2004.
99. Chabukdhara, M.; Singh, O.P. Coal Mining in Northeast India: An Overview of Environmental Issues and Treatment Approaches. *Int. J. Coal Sci. Technol.* **2016**, *3*, 87–96. [CrossRef]
100. Aranha, M.; Porwal, A.; González-Álvarez, I. Targeting REE Deposits Associated with Carbonatite and Alkaline Complexes in Northeast India. *Ore Geol. Rev.* **2022**, *148*, 105026. [CrossRef]
101. Mandal, K.; Dasgupta, R. Upper Assam Basin and Its Basinal Depositional History Kanailal Mandal and Rahul Dasgupta. In Proceedings of the 10th Biennial International Conference & Exposition, Society of Petroleum Geophysicists, Kochi, India, 23–25 November 2013; pp. 1–7.
102. Genovese, F.; Palmeri, A. Wavelet-Based Generation of Fully Non-Stationary Random Processes with Application to Seismic Ground Motions. *Mech. Syst. Signal Process.* **2025**, *223*, 111833. [CrossRef]
103. Rai, N.; Singha, D.K.; Chatterjee, R. Assessment of Paleocene to Lower Oligocene Formations and Basement to Estimate the Potential Hydrocarbon Reservoirs Using Seismic Inversion: A Case Study in the Upper Assam Shelf, India. *J. Pet. Explor. Prod. Technol.* **2022**, *12*, 1057–1073. [CrossRef]
104. Kumar, P.C.; Sain, K.; Omosanya, K.O.L. Geometry and Kinematics of Strike-Slip Faults in the Dibrugarh Field of the Upper Assam Foreland Basin, NE India. *Mar. Pet. Geol.* **2023**, *153*, 106291. [CrossRef]
105. Sangeetha, S.; Raghukanth, S.T.G. Broadband Ground Motion Simulations for Northeast India. *Soil Dyn. Earthq. Eng.* **2022**, *154*, 107120. [CrossRef]
106. Borgohain, J.; Borah, K.; Bora, D.K. Sediment Thickness beneath Shillong-Mikir Plateau and Its Adjoining Region of Northeast India Inferred from Teleseismic Receiver Function Modelling. *Himal. Geol.* **2018**, *39*, 47–56.

107. Kumar, T.S.; Bharali, B.R.; Verma, A.K. Basement Configuration and Structural Style in OIL's Operational Areas of Upper Assam. *AAPG Online J. EP Geosci.* **2012**. Available online: https://www.searchanddiscovery.com/documents/2012/50739kumar/ndx_kumar.pdf (accessed on 7 January 2025).
108. Ghosh, G.K.; Basha, S.K.; Kulshreshth, V.K. Integrated Interpretation of Gravity, Magnetic & Seismic Data for Delineation of Basement Configuration in Sadiya Block, Upper Assam, India. In Proceedings of the 8th Biennial International Conference and Exposition on Petroleum Geophysics, Hyderabad, India, 1–3 February 2010; pp. 2–7.
109. Saha, D. Integrated Analysis of Gravity and Magnetic Data in the Upper Assam Shelf and Adjoining Schupen Belt Area-A Critical Review. In Proceedings of the 2nd South Asian Geoscience Conference and Exhibition, GEOIndia2011, New Delhi, India, 12–14 January 2011.
110. Ravi Kumar, C.; Kesiezie, N.; Pathak, B.; Maiti, S.; Tiwari, R.K. Mapping of Basement Structure beneath the Kohima Synclinorium, North-East India via Bouguer Gravity Data Modelling. *J. Earth Syst. Sci.* **2020**, *129*, 56. [CrossRef]
111. Singh, P. An Integrated Approach in Geophysical Investigation—A Case Study of Kopili Valley, Assam Arakan Basin, India. In *SEG Technical Program Expanded Abstracts 2005*; Society of Exploration Geophysicists: Houston, TX, USA, 2005; pp. 659–662.
112. Pathak, B.; Syiem, S.M.; Mukherjee, K.; Chakrabortty, G.K. Gravity Magnetic Anomaly and Its Relation to Seismotectonic-Neotectonic Features around Kopili Valley Area, Brahmaputra Basin, Assam. *Indian J. Geosci.* **2014**, *68*, 401–420.
113. Sharma, R.; Gouda, H.C.; Singh, R.K.; Nagaraju, B.V. Structural Study of Meghalaya Plateau through Aeromagnetic Data. *J. Geol. Soc. India* **2012**, *79*, 11–29. [CrossRef]
114. Singh, A.; Singh, C.; Kennett, B.L.N. A Review of Crust and Upper Mantle Structure beneath the Indian Subcontinent. *Tectonophysics* **2015**, *644–645*, 1–21. [CrossRef]
115. Manglik, A.; Gupta, S.; Tiwari, V.M. Geophysical Studies for the Crust and Upper Mantle Structure of the Himalaya: Contributions of CSIR-NGRI. *J. Geol. Soc. India* **2021**, *97*, 1190–1199. [CrossRef]
116. Paul, H.; Gahalaut, V.K. Internal Structure of India: Perspectives from a Review of the Seismological Imaging Studies from 2020 to 2023. *Proc. Indian Natl. Sci. Acad.* **2024**, *90*, 442–455. [CrossRef]
117. Rai, S.S.; Prakasam, K.S.; Agrawal, N. Pn Wave Velocity and Moho Geometry in North Eastern India. *Proc. Indian Acad. Sci. (Earth Planet Sci.)* **1999**, *108*, 297–304. [CrossRef]
118. Kumar, M.R.; Raju, P.S.; Devi, E.U.; Saul, J.; Ramesh, D.S. Crustal Structure Variations in Northeast India from Converted Phases. *Geophys. Res. Lett.* **2004**, *31*, L17605. [CrossRef]
119. Ramesh, D.S.; Ravi Kumar, M.; Uma Devi, E.; Solomon Raju, P.; Yuan, X. Moho Geometry and Upper Mantle Images of Northeast India. *Geophys. Res. Lett.* **2005**, *32*, L14301. [CrossRef]
120. Kosarev, G.L.; Oreshin, S.I.; Vinnik, L.P.; Kiselev, S.G.; Dattatrayam, R.S.; Suresh, G.; Baidya, P.R. Heterogeneous Lithosphere and the Underlying Mantle of the Indian Subcontinent. *Tectonophysics* **2013**, *592*, 175–186. [CrossRef]
121. Bora, D.K.; Baruah, S.; Biswas, R. Moho Depth Variation in Shillong-Mikir Hills Plateau and Its Adjoining Region of Northeastern India Estimated From Reflected and Converted Waves. *J. Earthq. Sci.* **2014**, 1–25.
122. Bora, D.K.; Hazarika, D.; Borah, K.; Rai, S.S.; Baruah, S. Crustal Shear-Wave Velocity Structure beneath Northeast India from Teleseismic Receiver Function Analysis. *J. Asian Earth Sci.* **2014**, *90*, 1–14. [CrossRef]
123. Borah, K.; Bora, D.K.; Goyal, A.; Kumar, R. Crustal Structure beneath Northeast India Inferred from Receiver Function Modeling. *Phys. Earth Planet. Inter.* **2016**, *258*, 15–27. [CrossRef]
124. Anand, A.; Bora, D.K.; Borah, K.; Madhab Borgohain, J. Seismological Evidence of the Hales Discontinuity in Northeast India. *J. Asian Earth Sci.* **2018**, *154*, 238–247. [CrossRef]
125. Agrawal, M.; Das, M.K.; Kumar, S.; Pulliam, J. Mapping Lithospheric Seismic Structure beneath the Shillong Plateau (India) and Adjoining Regions by Jointly Fitting Receiver Functions and Surface Wave Dispersion. *Geophys. J. Int.* **2021**, *226*, 1645–1675. [CrossRef]
126. Kundu, A.; Hazarika, D.; Hajra, S.; Singh, A.K.; Ghosh, P. Crustal Thickness and Poisson's Ratio Variations in the Northeast India–Asia Collision Zone: Insight into the Tuting-Tidding Suture Zone, Eastern Himalaya. *J. Asian Earth Sci.* **2020**, *188*, 104099. [CrossRef]
127. Kundu, A.; Hazarika, D.; Yadav, D.K.; Ghosh, P. Crustal Thickness and Poisson's Ratio Variations in the Siang Window and Adjoining Areas of the Eastern Himalayan Syntaxis. *J. Asian Earth Sci.* **2022**, *231*, 105225. [CrossRef]
128. Saikia, S.; Baruah, S.; Chopra, S.; Gogoi, B.; Singh, U.K.; Bharali, B. An Appraisal of Crustal Structure of the Indo-Burmese Subduction Region. *J. Geodyn.* **2019**, *127*, 16–30. [CrossRef]
129. Bora, D.K.; Singh, A.P.; Borah, K.; Anand, A.; Biswas, R.; Mishra, O.P. Crustal Structure Beneath the Indo-Burma Ranges from the Teleseismic Receiver Function and Its Implications for Dehydration of the Subducting Indian Slab. *Pure Appl. Geophys.* **2022**, *179*, 197–216. [CrossRef]
130. Arora, B.R.; Prajapati, S.K.; Saikia, S.; Bansal, B.K. Crustal Structure of Northeast India as Evidenced by Receiver Function Imaging: Tectonic and Geodynamic Implications. *Int. J. Earth Sci.* **2024**, *113*, 733–755. [CrossRef]

131. Paul, H.; Mitra, S. Three-Dimensional Crustal Architecture Beneath the Sikkim Himalaya and Its Relationship to Active Deformation. *J. Geophys. Res. Solid Earth* **2017**, *122*, 7860–7878. [CrossRef]
132. Singh, A.; Bhushan, K.; Singh, C.; Steckler, M.S.; Akhter, S.H.; Seeber, L.; Kim, W.-Y.; Tiwari, A.K.; Biswas, R. Crustal Structure and Tectonics of Bangladesh: New Constraints from Inversion of Receiver Functions. *Tectonophysics* **2016**, *680*, 99–112. [CrossRef]
133. Anand, A.; Borah, K.; Mandal, S.; Bora, D. 3D Crustal Shear Wave Velocity Structure in Northeast India from Joint Inversion of Receiver Function and Rayleigh Wave Group Velocity. In Proceedings of the EGU General Assembly 2024, Copernicus Meetings, Vienna, Austria, 14–19 April 2024.
134. Bhattacharya, P.M.; Mukhopadhyay, S.; Majumdar, R.K.; Kayal, J.R. 3-D Seismic Structure of the Northeast India Region and Its Implications for Local and Regional Tectonics. *J. Asian Earth Sci.* **2008**, *33*, 25–41. [CrossRef]
135. Kayal, J.R.; Zhao, D. Three-Dimensional Seismic Structure beneath Shillong Plateau and Assam Valley, Northeast India. *Bull. Seismol. Soc. Am.* **1998**, *88*, 667–676. [CrossRef]
136. Kumar, A.; Kumar, N.; Mukhopadhyay, S.; Klemperer, S.L. Tomographic Image of Shear Wave Structure of NE India Based on Analysis of Rayleigh Wave Data. *Front. Earth Sci.* **2021**, *9*, 680361. [CrossRef]
137. Devi, E.U.; Kumar, P.; Kumar, M.R. Imaging the Indian Lithosphere beneath the Eastern Himalayan Region: Imaging the Indian Lithosphere. *Geophys. J. Int.* **2011**, *187*, 631–641. [CrossRef]
138. Mishra, O.P. Lithospheric Heterogeneities of Northeast India and Indo-Burma Region: Geodynamic Implications. *Geosyst. Geoenviron.* **2022**, *1*, 42. [CrossRef]
139. Bilham, R.; England, P. Plateau 'Pop-up' in the Great 1897 Assam Earthquake. *Nature* **2001**, *410*, 806–809. [CrossRef]
140. Rao, N.P.; Kumar, M.R. Uplift and Tectonics of the Shillong Plateau, Northeast India. *J. Phys. Earth* **1997**, *45*, 167–176. [CrossRef]
141. Chaudhury, J.; Mitra, S. Subcontinental Lithospheric Mantle Discontinuities beneath the Eastern Himalayan Plate Boundary System, NE India. *Geophys. J. Int.* **2023**, *233*, 2155–2171. [CrossRef]
142. Kumar, P.; Kumar, M.R.; Srijayanthi, G.; Arora, K.; Srinagesh, D.; Chadha, R.K.; Sen, M.K. Imaging the Lithosphere-Asthenosphere Boundary of the Indian Plate Using Converted Wave Techniques. *J. Geophys. Res. Solid Earth* **2013**, *118*, 5307–5319. [CrossRef]
143. Priestley, K.; McKenzie, D. The Relationship between Shear Wave Velocity, Temperature, Attenuation and Viscosity in the Shallow Part of the Mantle. *Earth Planet. Sci. Lett.* **2013**, *381*, 78–91. [CrossRef]
144. Pasyanos, M.E.; Masters, T.G.; Laske, G.; Ma, Z. LITHO1.0: An Updated Crust and Lithospheric Model of the Earth. *JGR Solid Earth* **2014**, *119*, 2153–2173. [CrossRef]
145. Srinu, U.; Kumar, P.; Haldar, C.; Kumar, M.R.; Srinagesh, D.; Illa, B. X-Discontinuity Beneath the Indian Shield—Evidence for Remnant Tethyan Oceanic Lithosphere in the Mantle. *JGR Solid Earth* **2021**, *126*, e2021JB021890. [CrossRef]
146. Saikia, D.; Kumar, M.R.; Singh, A. Palaeoslab and Plume Signatures in the Mantle Transition Zone beneath Eastern Himalaya and Adjoining Regions. *Geophys. J. Int.* **2020**, *221*, 468–477. [CrossRef]
147. Kumar, G.; Singh, A.; Tiwari, A.K.; Singh, C.; Ravi Kumar, M.; Saikia, D.; Uthaman, M.; Dubey, A.K. Alteration in the Mantle Transition Zone Structure beneath Sikkim and Adjoining Himalaya in Response to the Indian Plate Subduction. *J. Asian Earth Sci.* **2023**, *255*, 105768. [CrossRef]
148. Koulakov, I. High-Frequency P and S Velocity Anomalies in the Upper Mantle beneath Asia from Inversion of Worldwide Traveltime Data. *J. Geophys. Res. Solid Earth* **2011**, *116*, B04301. [CrossRef]
149. Singh, A.; Kumar, M.R.; Raju, P.S.; Ramesh, D.S. Shear Wave Anisotropy of the Northeast Indian Lithosphere. *Geophys. Res. Lett.* **2006**, *33*, L16302. [CrossRef]
150. Mohanty, D.D.; Singh, A. Shear Wave Birefringence and Current Configuration of Active Tectonics of Shillong Plateau: An Appraisal of Indian Plate Motion and Regional Structures. *Int. J. Earth Sci.* **2022**, *111*, 269–286. [CrossRef]
151. Mondal, P.; Mohanty, D.D. Mantle Deformation and Seismic Anisotropy beneath Northeast India Inferred from SKKS Birefringence. *Stud. Geophys. Geod.* **2021**, *65*, 36–52. [CrossRef]
152. Roy, S.K.; Kumar, M.R.; Srinagesh, D. Upper and Lower Mantle Anisotropy Inferred from Comprehensive SKS and SKKS Splitting Measurements from India. *Earth Planet. Sci. Lett.* **2014**, *392*, 192–206. [CrossRef]
153. Sharma, A.; Baruah, S.; Piccinini, D.; Saikia, S.; Phukan, M.K.; Chetia, M.; Kayal, J.R. Crustal Seismic Anisotropy beneath Shillong Plateau—Assam Valley in North East India: Shear-Wave Splitting Analysis Using Local Earthquakes. *Tectonophysics* **2017**, *717*, 425–432. [CrossRef]
154. Saikia, D.; Kumar, M.R.; Singh, A.; Roy, S.K.; Raju, P.S.; Lyngdoh, A.C. Mantle Deformation in the Eastern Himalaya, Burmese Arc and Adjoining Regions. *Geochem. Geophys. Geosyst* **2018**, *19*, 4420–4432. [CrossRef]
155. Kanaujia, J.; Surve, G. Upper Mantle Deformation beneath the Northeastern Part of Indian Plate from Shear-Wave Splitting Analysis. *Geo-Mar. Lett.* **2024**, *44*, 1. [CrossRef]
156. Mohanty, D.D.; Biswal, S.; Phukan, M.K.; Ayodeji, E.A. Possible Depth and Source Localization of Seismic Anisotropy beneath Shillong Plateau and Himalayan Foredeep Region: An Implication towards Deformation Mechanisms. *Geol. J.* **2022**, *57*, 5149–5160. [CrossRef]

157. Mohanty, D.D.; Mondal, P. Disparate Behaviour of Deformation Patterns beneath Northeast Indian Lithosphere Inferred from Shear Wave Splitting Analysis. *Phys. Earth Planet. Inter.* **2020**, *298*, 106315. [CrossRef]
158. DeMets, C.; Gordon, R.G.; Argus, D.F.; Stein, S. Effect of Recent Revisions to the Geomagnetic Reversal Time Scale on Estimates of Current Plate Motions. *Geophys. Res. Lett.* **1994**, *21*, 2191–2194. [CrossRef]
159. Ghosh, G.; Dasgupta, R.; Reddy, B.J.; Singh, S.N. Gravity Data Interpretation across the Brahmaputra Thrust and Dauki Fault in the North-Eastern India. *J. Geophys.* **2015**, *36*, 31–38.
160. Ravi Kumar, C.; Kesavan, R.; Ramachandrappa. Crustal Heterogeneities and Geothermal Gradients beneath Thrust and Fold Belts of Northeast India from Scaled Spectral Analysis of Aeromagnetic and Gravity Modelling. *J. Earth Syst. Sci.* **2022**, *131*, 145. [CrossRef]
161. Mahadevan, T.M. Evolution of the Indian Continental Lithosphere: Insights from Episodes of Crustal Evolution and Geophysical Models. *J. Indian Geophys. Union.* **2013**, *17*, 9–38.
162. Ghosh, G.K. Interpretation of Gravity Anomaly to Delineate Thrust Faults Locations at the Northeastern Part of India and Its Adjacent Areas Using Source Edge Detection Technique, Tilt Derivative and Cos (θ) Analysis. *Acta Geophys.* **2019**, *67*, 1277–1295. [CrossRef]
163. Ghosh, G.K. Automatic Thrust/Fault and Edge Location with Gravity Data across the Shillong Plateau and Mikir Hill Complex in Northeastern India Using the Most Positive and Most Negative Curvature Interpretation. *J. Geophys. Eng.* **2024**, *21*, 290–303. [CrossRef]
164. Jiao, L.; Tu, J.; Lei, Y.; Zhao, J.; Wang, W. Crustal Magnetic Structure and Implications for the Eastern Himalayan Syntaxis Revealed by EMAG2-V3. *Tectonophysics* **2025**, *896*, 230608. [CrossRef]
165. Abramova, D.Y.; Abramova, L.M.; Varentsov, I.M. Anomalous Lithospheric Magnetic Field over the Indo-Asian Collision Territory According to CHAMP Satellite Data. *Izv. Atmos. Ocean. Phys.* **2022**, *58*, 1077–1085. [CrossRef]
166. Rawat, M.; Anand, S.P.; Fathy, A.; Dimri, A.P.; Begum, S.K. Lithospheric Magnetic Anomaly Map of Indian Subcontinent (LAMI-1) from Swarm Satellite Data. *J. Earth Syst. Sci.* **2024**, *133*, 180. [CrossRef]
167. Berdichevsky, M.N.; Dmitriev, V.I. *Models and Methods of Magnetotellurics*; Springer: Berlin/Heidelberg, Germany, 2008; ISBN 978-3-540-77811-0.
168. Chave, A.D.; Jones, A.G. *The Magnetotelluric Method: Theory and Practice*; Cambridge University Press: Cambridge, UK, 2012; ISBN 978-1-139-02013-8.
169. Simpson, F.; Bahr, K. *Practical Magnetotellurics*; Cambridge University Press: Cambridge, UK, 2005; ISBN 0-521-81727-7.
170. Lin, W.; Yang, B.; Han, B.; Hu, X. A Review of Subsurface Electrical Conductivity Anomalies in Magnetotelluric Imaging. *Sensors* **2023**, *23*, 1803. [CrossRef] [PubMed]
171. Borah, U.K.; Patro, P.K.; Raju, K.; Reddy, K.C.; Babu, N.; Rao, P.R.; Rao, N.P. Role of Fluid on Seismicity of an Intra-Plate Earthquake Zone in Western India: An Electrical Fingerprint from Magnetotelluric Study. *Earth Planets Space* **2023**, *75*, 149. [CrossRef]
172. Harinarayana, T. Applications of Magnetotelluric Studies in India. In *Five Decades of Geophysics in India*; Memoirs of the Geological Survey of India; Geological Society of India: Bangalore, India, 2008; Volume 68, pp. 337–356, ISBN 978-81-85867-85-4.
173. Patro, P.K.; Kumar, P.V.V.; Sarma, S.V.S. MT/LMT Studies for Crust and Upper Mantle Structure of India and Its Adjoining Regions: Contribution of CSIR-NGRI. *J. Geol. Soc. India* **2021**, *97*, 1251–1259. [CrossRef]
174. Sanabam, S.S. Geophysical Studies of the Deep Crustal Structure of the North East Region Using Magnetotelluric Techniques. Ph.D. Thesis, North-Eastern Hill University, Shillong, India, 2010.
175. Varentsov, I.M.; Ivanov, P.V.; Lozovsky, I.N.; Bai, D.; Li, X.; Kumar, S.; Walia, D. Geoelectric Models Along the Profile Crossing the Indian Craton, Himalaya and Eastern Tibet Resulted from Simultaneous MT/MV Soundings. In *The Study of Continental Lithosphere Electrical Conductivity, Temperature and Rheology*; Zhamaletdinov, A.A., Rebetsky, Y.L., Eds.; Springer International Publishing: Cham, Switzerland, 2019; pp. 72–82.
176. Varentsov, I.M.; Bai, D.; Ivanov, P.V.; Kumar, S.; Li, X.; Lozovsky, I.N.; Walia, D. First Results of New Simultaneous MT/MV Soundings in the Eastern Tibet and NE India. In Proceedings of the 24th EM Induction Workshop, Helsingør, Denmark, 13–20 August 2018; pp. 1–4.
177. Varentsov, I.M.; Bai, D. Geoelectric Model of the Tectonosphere in Eastern Tibet Derived from Long-Period and Broadband MT/MV Sounding Data (Geoelektricheskaya Model Tektonosfery Vostochnogo Tibeta Po Dannym Glubinnykh i Razvedochnykh MT/MV Zondirovaniy). In *Problems of Geodynamics and Geoecology of Intracontinental Orogens, Proceedings of the 6th International Symposium, Victoria, BC, Canada, 8–12 June 2015*; Research Station of the Russian Academy of Sciences: Bishkek, Kyrgyzstan, 2015; pp. 1–10.