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Imaging challenges and mitigations in the Tripura Fold Belt areas for reservoir characterization and hydrocarbon prospecting

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ABSTRACT

Even though there have been substantial advancements in seismic data acquisition and processing, imaging in structurally complex regions like fold belts has seen only marginal improvement. In such geologically intricate areas, the conventional imaging approach may not yield satisfactory results. While 3D surface seismic surveys are preferred, acquiring 3D seismic data can be challenging due to logistical constraints. Moreover, the rugged terrain and difficult accessibility in these areas make 3D land seismic data acquisition prohibitively expensive. Conventional 2D land seismic data also has limitations, particularly in accurately imaging anticlinal features. An alternative to traditional 2D surveys in such contexts is the swath-line recording geometry. Swath-line recording offers significantly higher fold (720-fold in the present case), compared to typical 2D land surveys, resulting in data with an improved signal-to-noise ratio. However, several issues adversely impact imaging quality in thrust fold belts. Key factors affecting the quality of processed outputs include geometry, statics, and poor signal-to-noise ratio. Survey objectives may remain unmet unless these factors are addressed or minimized. We utilized a hybrid approach, combining multiple techniques including geometry corrections, nonlinear tomography-based statics solutions, velocity estimation using the CVS method, and leveraging different software suites and algorithms to address these inherent challenges.

Keywords: Tripura Fold belt, Swath-line, CMP line, S/N ratios, Semblance, Constant velocity stack method (CVS), PSTM

INTRODUCTION

Various factors negatively impact the quality of imaging in thrust fold belts. These include geometry, statics, and a poor signal-to-noise (S/N) ratio. Unless these issues are minimized or eliminated, the objectives of the survey may not be achieved. Moreover, processing parameters are highly sensitive to such complex data if the necessary remedies for the aforementioned factors are not considered. Therefore, a systematic approach is crucial to address these inherent problems. The fundamental prerequisites for a good seismic image include a good S/N ratio, a suitable and geologically compatible near-surface model for accurate statics calculation, a good subsurface velocity model, and the best imaging algorithm that fits the geological condition. However, processors in fold belt areas often face challenges in obtaining these processing ingredients easily, leading to significant challenges in processing. Efforts are made to address these major challenges and issues to achieve better data quality. However, no amount of processing effort can fully replace the importance of acquisition efforts. Despite advancements in seismic data processing and acquisition, the improvement in imaging in structurally complex areas like fold belts has been marginal. Traditional imaging methods have not yielded satisfactory results in such geologically complex locations. While 3-D surveys are preferred in these areas, collecting 3-D land seismic data is not always feasible or economical due to issues such as difficult terrain and limited accessibility. The limitations of conventional 2-D land seismic data become especially apparent in fold belt areas, where accurately capturing the anticlinal section can be a challenge.

The aim of the present study is to devise a workflow specifically for the Tripura fold belts, making use of the existing legacy seismic data in our area of study. We are concentrating on tackling various challenges that affect image quality, such as geometry, statics, noise, velocity, and algorithms. When it comes to new data acquisition, our approach is to gather high-quality seismic data using innovative geometry, while taking into account the logistics, scheduling, and cost-effectiveness of fold belt operations. We investigate the viability of 2-D swath-line geometry as a potential solution for the Tripura fold belt region, and present a comparative discussion on the acquisition, processing, and results with traditional 2-D methods in our case study.

STUDY AREA

The Assam and Assam Arakan basin is an onshore basin situated in the north-eastern part of India and has been categorized as a Category-I basin (Rajkhowa et al.,2018). On the basis of morphological characteristics, the Assam and Assam-Arakan basin (A&AA Basin), is subdivided into a foreland and a fold belt. The foreland comprises of area including the Brahmaputra arch and it's southern and northern slopes and is commonly known as Upper Assam Shelf North (UAN); the area encompassing the south eastern slope of Shillong and Mikir Massifs is commonly known as Upper Assam Shelf South (UAS). The A&AA Fold Belt comprises the Naga Schuppen Belt and sigmoidal en-echelon folds of Tripura-Cachar-Fold Belt.

The geomorphology of fold belt is typified by a succession of hill ranges and valleys of meridonial and sub meridonial trends (Dasgupta and Biswas, 2000). The height of these ranges varies from 200 to 500 m. The general elevation increases to the east in the region. Fold-belt has complex evolution history and