

# Logistics- Is it Really an Issue for Acquiring Seismic Data ? A Case History in Mizoram NELP Block of India

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## Summary

The tectonic setting, geological history and proven discoveries of hydrocarbons in area adjoining to Mizoram prompted ONGC to restart its Exploration activities in Mizoram. Logistically the area is extremely difficult which is hilly with thick forest and rapid drastic elevation changes and geologically very complex due to faulting, folding & thrusting of beds. Logistically difficult area had always been the challenges for seismic crews to acquire the data. Problems are further complicated if the sub-surface geology is highly complex. To carry out seismic survey in Mizoram was a big challenge due to above mentioned difficulties. In this paper the methodologies/ strategies adopted by a Seismic crew of ONGC, Jorhat to acquire seismic data, overcoming tough logistic conditions and geological complexities are explained. The paper also explains the initiation taken in QHSE and Public relations aspects. As a synergistic approach the seismic crew coordinated other three surveys viz. Geological, Geochemical and Gravity-Magnetic survey to improve the level of confidence for delineating the subsurface geological features. The crew had clearly made a break through in acquiring good quality data that too also without any accident in this most difficult terrain and maintained excellent relations with local public

## Introduction

With the spiraling rising cost of crude and energy in the international market, Government of India under the NELP regime through DGH offering new relatively unexplored blocks to prospective E&P companies. Some of these blocks are unexplored so far due to difficult logistics. Mizoram NELP block is one of them which was offered to ONGC in NELP-III in 2002. The area falls in Kolasib district of Mizoram state (Fig. 1). The surface topography of the area of seismic operation is that of a typical Northeastern rugged hilly terrain of India. The topographic features are highly undulating with thick forest cover. The hillocks are as high as 700 m with intervening

very deep gorges. This made communication & movement in the field impossible. The details of topographic elevations, forest cover and other surface features can be seen from figures-2 & 2a. There are no approach roads and no water for drilling shot holes. The area being very remote, arranging supplies and logistic support were big problem. Language and cultural differences and medical services were another problem.

Geologically the area of operation forms a part of Tripura-Cachar-Mizoram fold belt of Assam-Arrakan basin where formations of Neogene sequence are exposed. The rocks of this region were laid down during late Cretaceous-Tertiary time in a basin that was formed by the closing of

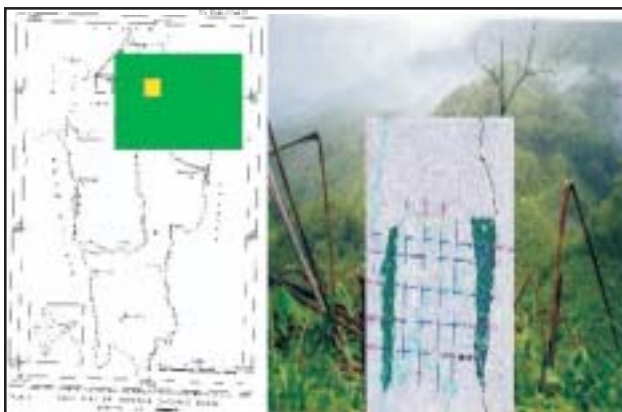


Fig. 1: Location map of the area

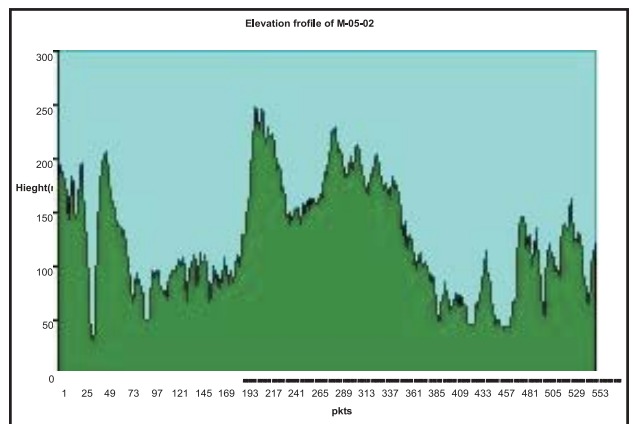
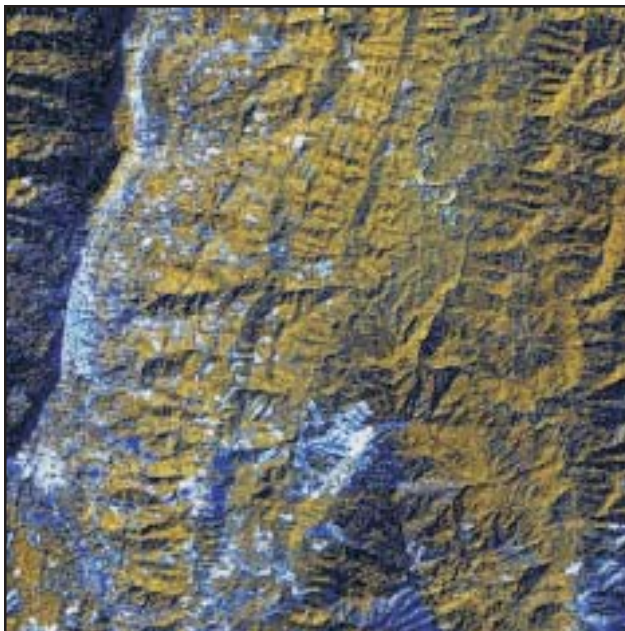


Fig. 2: Elevation profile along a line in Mizoram



**Fig. 2a** : Satellite map of area (Mizoram)



**Fig. 3** : Geological and basement map of Mizoram

the Indian and Burmese plates Mizoram fold belt is composed of tight linear folds (with their axes almost in north-south direction) . The intensity of folding increases from West to East where the rocks of Indian plate subducted below the Burmese plate. As per the available geological cross-section of the proposed area of operation (Figure. 3), the area has Tipam formation exposed in the central part and Bokabil formation is exposed on the eastern and western part. From the Aeromagnetic data (Mehra et al, 1988), the structural features of basement seem to have an east-west trend. Exposed geology and basement features trending orthogonal to each other ( Fig. 3) which suggests that the surface geology is controlled by thin skin tectonics. More than 6000 m thick clastic sediments were deposited in the Miocene trough. This period of subsidence was followed in the late Miocene and early Pliocene time. The erinaceous unit of Barails (Renji) and those of unexposed Lower Bhuban are expected to provide good reservoir rocks. . Middle Bhuban is mainly of shale, which can act as a regional cap rock, and the shale within Lower Bhuban may also act as cap rock locally.

Based on the information from adjoining areas, the area of operations seems to be very prospective. The adjoining Tripura and Bangladesh in the West, Cachar in the North and Myanmar in the East have so many oil & Gas producing fields. Bounded by these oil bearing fields, Mizoram is unexplored so far due to tough topography and difficult logistics. There are two most challenging problems

in the area. First one to overcome the logistics difficulties and the second to overcome complex geology to meet the technical objective by acquiring the data of desired quality. This paper elaborates the skills and efforts of a seismic crew of ONGC from Assam & Assam Arrakan Basin of India which was deployed to acquire the 2-D seismic data in this most difficult terrain.

## **Tackling the logistics problems**

### **A. Establishment & supplies**

First problem was to arrange the supplies and to make the stay of the team comfortable in these remote and hostile conditions. For that matter Party decided to operate from two camps. The operational area is so remote that keeping the entire crew in the remote place where basic facilities like medical, safe drinking water, transport and communication are not available, was risky. To make the stay comfortable main camp was established at Kawnpui, a hill town at National highway. To minimize the travel time the operational camp with temporary Explosive magazine site was established in the working area at Hortoki village. Most of the supplies like explosive, stores & spares, provisioning drinking water, banking were arranged from Silchar town( 130 Km from camp). The facilities like Hutments for housing 27 persons including the staff of GSI and 4 offices with electrification telephone connection. SAP connection, HF control room, Electronics workshop, mess, sports & entertainment etc. were maintained in the main camp. This camp being at Hill top was very comfortable as the temperature and atmosphere was very conducive for health. Due to this reason, during the survey period not a

single person fell sick and there was no work loss due to illnesses contrary to the earlier campaigns when most of the time crew members fell sick. The camp was on Silchar-Aizawl highway and all the time transport was available to Silchar/ Aizawl .to meet the emergencies.

Temporary explosive magazine was established near partial camp. Explosives were brought from ONGC's main magazine at Silchar which was a very time consuming job but it was planned & executed very efficiently to meet the explosive requirement. Repairing of ground electronics units and Battery charging carried out from partial camp. There was a direct HF link between the two camps.

## B. Approaches to the lines

To acquire the data next problem was to reach the lines with man & equipments as there were no approach roads to the lines.. The area is full of thick forest, very deep gorges, highly steep hills where even foot tracks did not exist in majority of the area. Before starting stacking work, along each line lot of bush cutting and step making to walk in hills was necessary. To take the heavy vehicles and equipments nearer to the lines three existing foot tracks were converted into motorable tracks with the help of JCB (Figure-4), which is used to level the ground. JCB was hired on rental basis and was utilized through out the work. No flora and fauna of the area was disturbed by doing this job. Total 26 Km motorable tracks were made in the area which will also be very useful for the local villagers while doing Jhoom cultivation in the jungle.

## C. Topographic survey work

In this area to carry out topographic work of desired accuracy was a big challenge. The area is of varying topography comprising of small to high hills, abrupt changes



Fig. 4 : JCB making road in the jungle

in the slope, deep Nalas, thick dense forest of mainly bamboo and no proper approaches. The survey in this area was difficult, challenging and adventurous. Prior to start of the topographic survey GPS network was planned to encompass the operational area and the control points were fixed accordingly to start the survey work. Various GPS control points were fixed for cross checking the stacking and leveling work. The profiles were stacked with the help of prismatic compass by calculating magnetic bearing after applying the necessary magnetic declination to the grid bearing between the control points. The linear measurement of the profiles were done either by stepping method or by applying slope correction to the distances so as to get measured distance equal to group interval. The measured distances were checked with the help of EDM frequently and alignment of profiles was ensured by fixing the GPS Station along the profile . The leveling of Kawnpui GPS point( 850 m) was carried to Hortoki(30 m) with the help of Auto level and total 8 TBM were established to carry out leveling along the lines which was checked at every 500 m with the help of GPS & "Total Station". The positioning loop misclosure error was 1:1000000 and leveling error was below 0.01

## D. Drilling of shot holes

Since the area is devoid of water for rotary drilling and hard rock formations are exposed in the area, first time pneumatic compressor based dry drilling was introduced to address the drilling difficulties. Two types of man portable mechanized pneumatic (DTH Type) rigs were deployed. The rigs were capable of drilling shot holes upto 35 m and upholes upto 70 m. The core cutting/ dust was flushed out by air supplied by a compressor via a hose pipe. One compressor could handle up to 7 rigs with 1000 m hose pipe and 4-5 rigs with 3000 m hose pipe. It was a Herculean task to shift the rigs from one point to another in this dangerous area. Usually rigs and compressor were left on the line and 3-4 laborers used to guard them. Jungle roads constructed with the help of JCB were used to take the compressors and tractors to the field nearer to the lines from where hose pipes were laid down up to the rigs. This is to be mentioned here that in spite of all such logistics problems drilling had never been allowed to be a problem through effective planning, very effective technology, highly skilled and devoted operators .A picture of the rig with compressors is shown in Fig.5

## E. communication in the field

As the area is highly undulating and covered with thick forest mainly bamboo, communication of the observer



Fig. 5: Portable DTH rig(below) with compressors(above)

with linemen and shooting crew was not possible since the line of sight was hardly 5 m. Shortage of Porto phones further increased this problem. After lot of struggling and experimentation party devised a methodology and set up a control room at hill top in the main camp. This control room being at height, communication of observer and linemen with the control room was flawless(Figure-6).

Every instruction / suggestions to the line men and shooting crew was passed on to control room from instrument position which was passed on to the corresponding line men/ shooter and vice versa and the task was performed. . This technique helps to locate and search

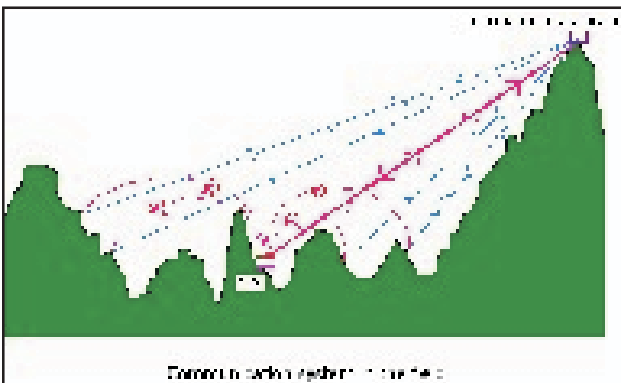


Fig. 6 : communication system in the field & camp

the crew members in the remote field especially the topographic survey crew and uphole survey crew.

### F. Portable operation of SN-388

As the instrument van could not be taken to the field, the entire production work was carried out in head load mode. For recording the upholes as well as regular data crew members had to walk 5 to 10 km daily. Walking with load of cables and geophones and spreading them in this rugged terrain was very troublesome and time consuming. Daily spreading and lifting the cables was not possible at all. Symmetric Split Spread of 6.60 km further complicated the problem. To overcome this hurdle party decided to leave the cables, geophones and other units in the field. The contractor was asked to deploy some guards in the field at regular interval to safeguard the material. The cooperation of Village Council President in implementing this methodology is highly appreciated. Batteries were brought to partial camp for charging. Next day only advance line was spread. And the back line was lifted as decided by the observer. To carry the cables / geophones to the field services of boats and local wooden man driven cart were adopted.

The instrument van could not be taken to the lines due to the unsafe jungle track. Therefore most of the time crew members had to walk several Km to reach the line. These difficulties are shown in Figures-7, 8, 9 & 10

### G. Local problems

Language, culture and society of Mizoram are entirely different than the other parts of the country. Initially there were problems dealing with local people. Later on crew could develop good relations with them. For that crew organized a football tournament, arranged field visits of various school children, and arranged various visits of the local authorities including the Honorable Chief Minister of Mizoram(Fig. 11), Honorable Lok Sabha M.P. from Mizoram etc. Crew provided water to needy people in this water scarcity area at various occasions. Measures for socio economic development were also taken eg. Financial aid to two NGO's Viz. YMA and VCP(Hortoki), the tracks made in the jungle and commitment of at least one contingent laborer from each family of Hortoki village. Small jobs like painting and making of sign boards were also got done through local unemployed youths. All these measures paid dividends in the form of whole hearted cooperation from the local public.



Fig. 7 : Cable transportation through boat

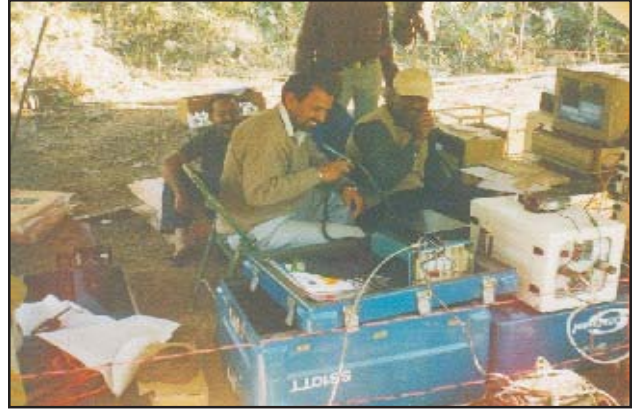


Fig. 9 : observers operating SN-388



Fig. 10 : observers operating SR unit



Fig. 8 : Geophone plantation & depth monitoring



Fig. 11 : CM(Mizoram) being greeted by GM(GP)

### Tackling the geological complexities

The next challenge in this geologically complex area was to acquire meaningful data because of faulting folding and thrusting of beds and highly variable nature of near-surface geology. recording the reflection events was a big challenge. It could be overcome in three steps (a) selection of proper recording geometry through modeling and empirical calculations based on knowledge acquired

from previous Geo-scientific data of the area, (b) to ensure proper energy penetration through determination and implementation of Shot hole depths through precise near surface models prepared from Uphole data and other experiments conducted in the field and (c) maintaining the desired quality of data by minimizing the bad / dead traces



and by minimizing the data gaps in the form of skip/ rejected shots. A short description of the above aspects is given below:

### A. Finalization of field parameters

Intensive modeling exercises and other empirical calculations were carried out before finalizing the field parameters. Ray trace modeling was carried out at Regional Computer Centre of ONGC, Jorhat on the geological model prepared from available previous Geo-scientific data (Figure-12). After analyzing the synthetic sections ( Like shown in Figure-13), it is observed that the 256 channel symmetric split spread shooting is required to illuminate the entire geological model. Based on the Modeling studies and empirical calculations following parameters were approved for acquiring the data in the area

- (1) Type of Shooting : Symmetric Split Spread
- (3) No. Of Channels : 128+128 = 256
- (4) Fold : 2\*32

### B. Determination of Shot hole depth

Precise near surface models (Figure-14) were prepared based on the uphole data and point to point depth was defined for drilling. Near surface model was prepared

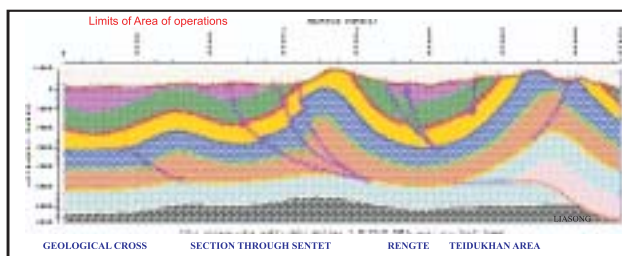


Fig. 12 : Geological model for modeling In Mizoram

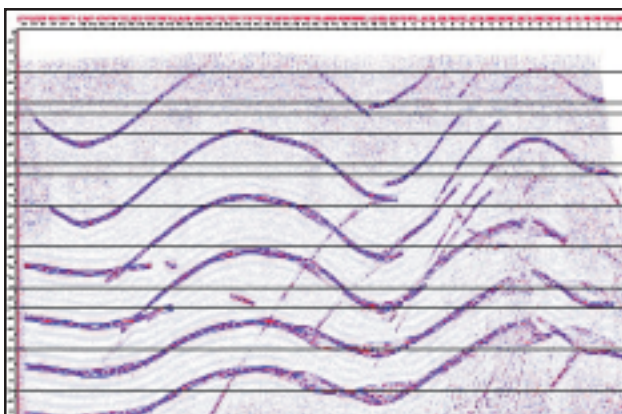


Fig. 13 : Synthetic section along a line in Mizoram



Fig. 14 : Near Surface model along a line

using the state of the art software. In the field shot hole depth was strictly monitored to ensure the energy penetration. Efforts were made to drill 4 m deep over hill tops and 4 m less in the valley parts along the lines since the experience on uphole data showed more weathering thickness over hill tops and less over low lying areas due to erosion of loose formations during rains. In the absence of core cuttings from the upholes due to dry drilling, pulse shape was taken into consideration while deciding the operating depth along with the velocities of near surface layers. The charge size was varied depending upon the results of charge size experiments done from time to time and by observing the energy in monitor records on Field processing unit. This approach paid dividend as the energy penetration could be maintained.

### C. Minimizing the faulty channels

The third aspect to acquire the data of desired quality is to minimize the faulty channels like dead, leaky, noisy reverse channels. This could be done by ensuring perfect geophone plantation with least tilt and perfect coupling. Before start of each line all the cables, geophones, SU/ PSU/ CSU etc were tested through TAP test ( Figure-15 ). The faulty units were segregated. These faulty units were repaired in the seismic workshop of the party in the main camp. After repairing geophones were tested on SMT-200 geophone analyzer and cables and other units were tested with line tester. On all the cable and geophone takeouts, Amphib connectors were fitted to get rid of polarity reversals. Any channel found with reverse polarity on the monitor record before start of field work was immediately got corrected. Daily all the required field and other tests of the instrument like tilt were taken before start of the work. In spite of the difficulty in effecting corrections in the field due to very difficult terrain, efforts were made to keep Tilt below 5 % for this purpose.



Fig. 15 : TAP test of ground electronics in Progress

On micro level data quality was monitored on FPU. To see the frequency content and amplitude level spectrums( Figure-16) were generated at every 1 km interval along the lines. And retrieval of data was checked on FPU. Brute stacks generated on FPU showing patchy reflections. In this area, statics playing vital role. Utmost care taken on calculating the velocities, layer thicknesses and elevations for computing the static correction on the data.

### Health, safety & environment

All the safety measures were taken to protect the instrument from damage by properly checking and maintaining all the equipments manpower from being injured by following all the safety instructions and by using safety devices Through out the working period, top priority was given to maintain good health of the crew. No damage was done to the flora & fauna of the region. The crew closed its operations without any accident. Crew was awarded ISO-9001, ISO-140001 & OHSAS-180001 certification on QHSE aspect.

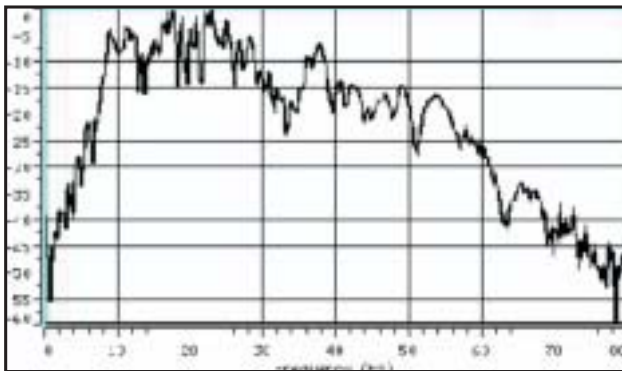


Fig. 16: Frequency spectrum on Raw shot data

### Conclusion

A breakthrough had been made in carrying out exploration activities in logistically difficult hilly area with a great success. Crew had clearly demonstrated that logistics should not be an issue while planning to acquire seismic data Good reflection events are seen on the processed sections of lines ( Figures- 17, 18, 19 ). The four different surveys viz. Seismic, Gravity-Magnetic, Geological & Geochemical carried out successfully from a single camp In spite of the area being very difficult logistically, operations

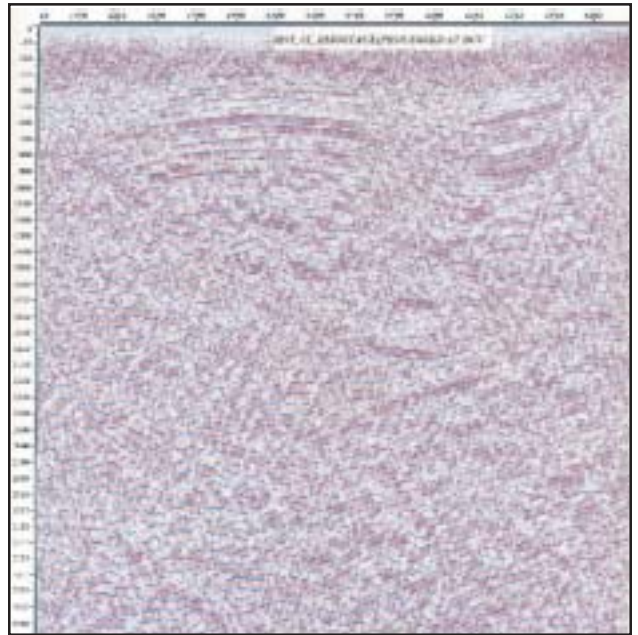


Fig. 17: Processed section of line in Mizoram

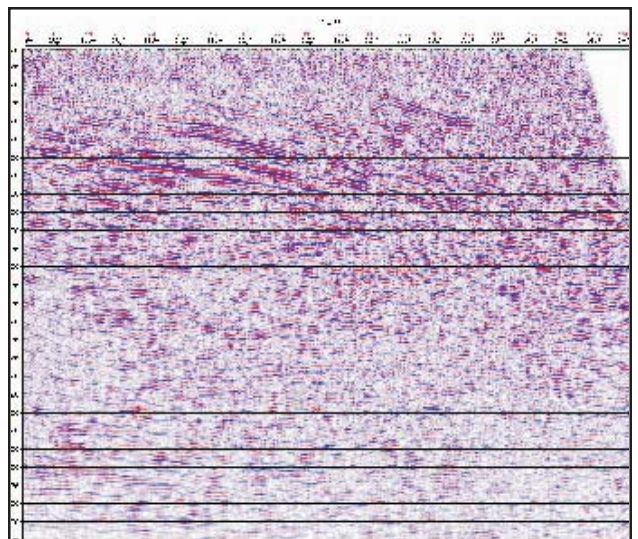


Fig. 17: processed section of another line

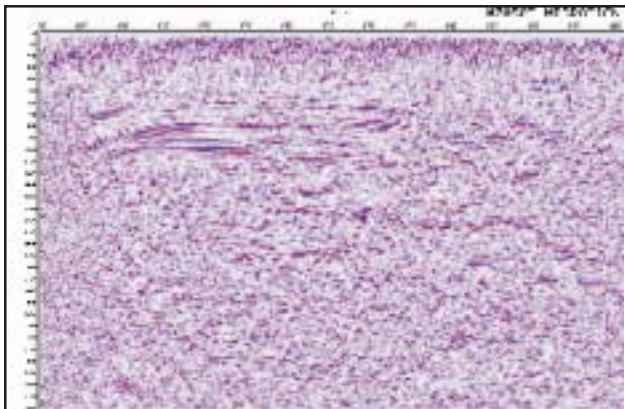


Fig. 19: Processed section of a line in Mizoram

were closed without any casualty and accident. QHSE norms had been fully implemented which is evident from the fact that during the operations not a single person fell sick .all the inputs were maintained to make them fully operative and productive. Excellent harmonious relations developed with the local public will go very long in future while carrying out further activities in the State. This data will be of great help in depicting the sub-surface features for guiding further exploration activities in Mizoram and ultimately will be translated into reserve accretion in the area.

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### Abbreviations

ONGC	: Oil & Natural Gas Corporation Limited
A & AA Basin	: Assam & Assam Arrakan Basin
NELP	: New Exploration Licensing Policy
DTH	: Double Tone Hammering
JCB	: Japan Crush Body
FPU	: Field Processing Unit
SU	- Station Units of SN-388 Recording System
PSU	- Power Station Unit
SR Unit	: Shallow Refraction Unit for Upholes
SI	: Shot Interval
GI	: Group Interval
SSS	: Symmetric Split Spread
ASS	: Asymmetric Split Spread
MZP	: Mizoram Zirlai Paul , student union in Mizoram
YMA	: Young Mizo Association
VCP	: Village Council President
RCC	: Regional Computer Centre
REW	: Regional Electronics Workshop
GPS	: Global Positioning System
GTS	: Great Triangulation Survey
DGH	: Directorate General of Hydrocarbons
KDMIPE	: Keshav Dev Malviya Institute of Petroleum Exploration
CM	: Chief Minister
MP	: Member of Parliament
QHSE	: Quality, Health, Safety and Environment
TBM	: Temporary Bench Mark
DTH	: Double Tone Hammering
NGO	: Non Government Organization