Application of High Resolution Seismic Survey in CBM Exploration – A Case study, Sohagpur West Block, Madhya Pradesh

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Summary

Coal Bed Methane (CBM) is a natural gas produced from the coal seams. Coal Bed Methane is a mixture of hydrocarbons, dominantly methane with other minor amount of other gases like carbon dioxide and nitrogen. Coal Bed Methane is generated either from a biological process as a result of microbial action or from a thermal process as a result of increasing heat with depth of the coal. High rank coals buried at great depths (>300-1200m) are suitable for the exploitation of coal bed methane (CBM). Identification of faults, thickness and depth of coal seams are very much essential in CBM exploration as these factors are responsible for the formation of Methane. 2D High Resolution Seismic Survey plays a unique role in mapping coal seams and also their fine structure comprising small-scale faults. In this technique the property of acoustic impedance is of much importance in identifying different rock formations, which are associated with coal, and it has been successfully implemented. The study area is situated in the central part of Sohagpur coalfield, which forms the southern part of Rewa master Gondwana Basin in large Sone- Narmada valley of central India. In the Sohagpur Coal fields, Barakar is the main coal bearing formation. The barakar formations are traversed by a number of basic dykes and sills. The HRSS method is applied in 1 Sq.Km area of Sohagpur coalfield along 10 profiles covering 9.20 line Km and coal seams as well as structural features at the depth range of 300 – 450 m.

Introduction

The High-resolution reflection seismic method (HRSS) is used extensively for the study of the subsurface features for a variety of targets in different areas6, 7. HRS surveys are extensively used, in recent times; to map the Coal seams up to a depth of 1000m and also establishing the coal seam continuity and reflectivity in the subsurface. The Coal beds occur below 300m to >1000m may be classified as High rank coals. Generally these high rank coals contain Methane gas. This methane gas is known as Coal bed methane (CBM) which is free methane found in coal seams. The presence of high rank coals may be the indication of CBM horizons5.

The High-resolution seismic reflection survey was carried out at Sohagpur, Madhya Pradesh to determine the high rank coals below 300m to 600m. The HRS survey carried out over ten profiles with a shot interval of 10m and 5m-receiver interval covering 9.20 LKM. The lines were shot across the strike of the formations in a Northeast – Southwest direction. The quality of the data was checked in the field using Winseis software and processed using the PROMAX software.

Geological setting:

The survey area comes under Sohagpur Coalfield, which is a part of the large sediment filled Gondwana trough located in the drainage basin along the Son River. Structurally it is a half graben. The prominent structural feature of the Sohagpur coal field is the system of ENE-WSW to east-west trending sub parallel faults2. In the Sohagpur coalfield, Barakar is the main coal bearing formation. Eight to ten
coal seams have been developed in the upper part of the Barakar formation. There are five to seven coal seams of regional nature and occur at depths of 250-900 m within the blocks although the lower part of the Barakar formation contains coal beds in the Sohagpur coalfield, they are generally locally distributed, relatively thin, and are presently uneconomical. In addition, multiple coal seams with carb shale interbeds are present in Ranigunj formation at shallow depths of 50-350m. Dykes of Dolerite are quite common both in eastern and western parts of the field. The average density and velocities of the coal and its associated formations are shown in the table 1.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Formation</th>
<th>Density (gm/cc)</th>
<th>Velocity (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sandstones</td>
<td>1.60 - 3.26</td>
<td>1400 – 4420</td>
</tr>
<tr>
<td>2</td>
<td>Shales</td>
<td>1.56 – 3.2</td>
<td>2250 – 4695</td>
</tr>
<tr>
<td>3</td>
<td>Dolerite</td>
<td>2.52 – 2.81</td>
<td>3300 – 5800</td>
</tr>
<tr>
<td>4</td>
<td>Coal</td>
<td>1.2 – 1.8</td>
<td>1100 - 2800</td>
</tr>
</tbody>
</table>

Table: 1 Seismic velocities and densities of the formations

Field Procedure

The seismic survey was done using 10Hz natural frequency geophones groups with endon spread configuration. Common depth point technique (CDP) was used to acquire the field data. This technique will help to cancel the long wave length noise during the data acquisition. The stratavisor NZ–II a 60-channel seismograph was employed with a sample rate 0.25msec, record length 2Sec. Each seismogram/shot gather record is composed of 60 channels and one channel (61) to record the up hole time near the shot point. The final field parameters are chosen based on experimentation carried out in the field. The data acquisition was done with the shot point interval of 10m and geophone interval of 5m. The above configuration results into 15 fold coverage.

Data Processing

The processing sequence was very similar to that used in petroleum industry; however, certain refinements in processing and interpretation are needed to fulfill the requirements in shallow HRSS. The high quality of the reflection data obviated the need for special noise attenuation techniques. In the first step, the data was converted from SEG2 to SEG-Y format. Data was arranged sequentially and high amplitudes noise, polarity reversals, bad traces etc. were removed. Time delays are corrected, due to the variation in elevation and top weathered layer, by reducing the data to an arbitrary datum plane. These static corrections are made using refraction data and up hole survey results. First arrival statics are also used.

Spectral and velocity analysis are performed. First arrivals and later refracted events muted out. CDP gathering was done by incorporating the source-receiver geometry of all the shots recorded by way of defining the physical location of shots and their respective receiver positions. Multi-offset CDP traces are transformed to zero-offset traces prior to stack such that all the events are added in phase. All traces in a CDP gather are corrected for NMO using a range of velocities, then summed and plotted as velocity Vs time. F-K filter was applied on shot gather data to remove the ground roll effect. In shallow HRSS studies subsurface velocity information is a crucial factor. Velocity information can be obtained through velocity analysis of the surface reflection data. There are several velocity analysis tools available in processing software. Two such tools namely “Constant Velocity staking” and “semblance analysis” are used in the present data processing. The processing flow diagram is shown (figure. 1). Seismic stacked sections along four lines viz., Profile 1, 2, 3, and 4 are shown in figures 2, 3, 4 and 5 respectively.

Discussion of results

Profile 1

In this seismic section (figure 2) reflections have been observed between 300-420ms and minute structural disturbance can be seen between picket position 1122.5 and 1722.5 which may be resulting the presence of fault.

Profile 2

In this seismic section (figure 3) reflections have been observed between 290-320ms. Along this line no major structural disturbance is observed.

Profile 3

In this seismic section (figure 4) reflections have been observed between 320-360ms. Along this line minor structural disturbance is observed.
Profile 4
In this seismic section (figure 5) reflections have been observed between 340-400ms. At around 800 picket position minor fault is observed. From picket number 800-1100 reflections have been observed at 620-700ms.

![Seismic Data Processing Steps](image)
Conclusions

In the study area the coal seams are observed from 290 ms to 400 ms with southern dip. Some structural events are also seen in seismic sections and some of them may be due to faults. The analysis of seismic time/depth section reflects coal seams with geological features like fault zones.

Fig: 4 Profiles - 3

Fig: 5 Profile - 4
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References


