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2D HRSS for mapping of Coal seams – A case study in South Cambay Basin

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Summary

2 D High Resolution seismic Survey with high frequency geophobnes SM_7 having Natural freq. 30 Hz for mapping of coal seams was conducted in the coal mining block Vastan area in South Cambay basin of Gujarat. The highly encouragebale result of seismic survey gives an inference for effective designing of underground coal gasification.

Introduction

The business of hunt for oil & gas has come to a full cycle world wide as most of the easily exploitable reserves are either explored or exploited. As the need of energy is growing exponentially, all the players in energy sector are busy in looking for alternative sources of energy.

As the major player of energy sector in our country, ONGC is also not behind the race in looking for probability of utilizing sources of energy other then liquid & gaseous hydrocarbons such as coal bed methane, gas hydrates, under ground coal gasification etc. Though there is a sizable amount of coal reserves available in our country, most part of it can not be mined due to either technological or environmental reasons. Need of the hour is to find out new technology to bring out a maximum part of the un-exploitable coal reserves to the surface which can give some respite to the traditional sources of energy.

Along with other players in energy sector ONGC with vast experience of E&P business, is also looking for under ground coal gasification as one of the promising field for meeting the energy need of the country. In this process traditional seismic method with some modification can be a pivotal tool for delineating un-exploitable coal reserves and their recovery in the form of valuable gas. The following are some of the geophysical methods employed in the international arena:

- High-resolution surface seismic reflection and refraction
- Borehole geophysics: logging, VSP, & tomography
- Underground inseam seismic

The traditional 2D or 3D seismic is not sufficient to delineate the coal seams and hence high resolution seismic surveys are the possible tool for the exploration of coal seams. Presently, ONGC in consultation with the SIM, Russia has identified a site in the southern part of Gujarat for its Pilot study of UCG using high-resolution seismic as a tool for delineation of coal seams.

The challenge of acquiring high resolution seismic data was entrusted to GP- 36, Geophysical Services, Western Onshore Basin, Baroda.The quantum of work assigned involves acquiring the HRSS data along two profiles, one along the strike direction and the other in dip direction.

Objective

To map the multiple Lignite seams embedded within clay

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Target Depth	:	150 m. – 500 m.
Thickness of individual seam	:	0.5 m. to 5.0 m.
Dip of Lignite seam	:	20 to 60

Challenges ahead

1. Earlier seismic data were acquired for deeper objectives.

2. No ONGC well in the operational area.

3. No Log data in the shallow wells drilled by GSPCL.

4. Dense sugar cane in the operational area :-

   - Group Interval of 5 m.
   - Shot point interval of 10 m. (shots between pickets)
   - 2 Lines each of live #192 to be laid side by side.

5. Only one narrow approach road in the survey area along a canal.

6. Sampling Interval of 0.5 millisecond :-

   - Limited channel capacity of Ground electronics (One Cross Station Unit can handle maximum # 150 for 0.5 m. sec SI)
   - Limitation of Recording Instrument (One Portable Acquisition Module can record maximum # 275 for 0.5 m. sec SI)

Planning

1. Study of the earlier available Geo-scientific data.

2. Thorough reconnaissance survey of the area.

3. A walking corridor of 2 m. wide were made in the sugar cane field after lot of persuasion and series of meetings with the farmers, panchayats with the assurance to pay compensation within a fortnight.

4. Staking and Leveling of all pickets by DGPS unit (nearby BM at Olpad, about 35 Km. from the area)

5. Collection of High Frequency Geophones (SM7, 30 Hz natural Frequency) from Chennai.

6. Analyzing and Testing of 350 nos. of SM7_30Hz geophones and 350 nos. of SM24_10Hz geophones by SMT 200 Geophone Analyzer followed by TAP test .

7. Two Portable Acquisition Module units were integrated by REL, ONGC Vadodara so that, 384 live channels could be recorded with 0.5 m. sec SI.

8. Each seismic line of 192 live channels for SM7_30Hz geophones and SM24_10Hz geophones were bifurcated into 2 lines (#150 + # 42) to counter the channel limitation capacity of Cross Station Unit.

9. Near Surface Models were prepared for one Dip Line and other Strike Line after conducting 19 nos. of Uphole surveys for optimizing shooting medium and calculation of static correction. The model shows a consistent high velocity medium ranging from depth of 17.0 m. to 24.0 m.

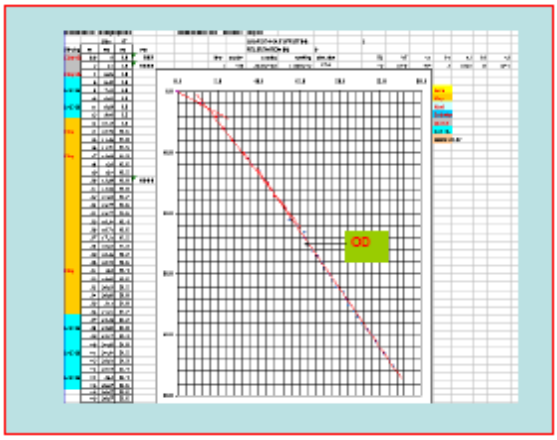

Figure 1: Representative Uphole plot at a Pkt in Strike Line

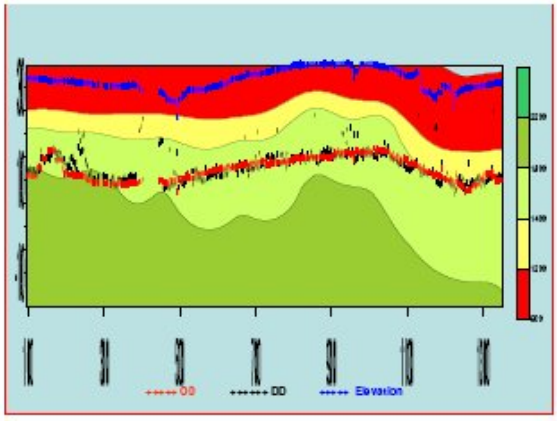

Figure 2: Representative Near surface Model of Strike Line

Data Acquisition Parameter

Following parameters were decided after desk calculation and series of interactions with the team from IRS, Ahmedabad.

No. of live channels	:	192 (96 + 96)
Foldage	:	48
Group Interval	:	5 m.
Shot point Interval	:	10 m. (shots between pickets)
Instrument	:	SN388 (2 PAM used)
Sample Interval	:	0.5 m sec.
Record length	:	3.0 sec.
Near / Far offset	:	2.5 m. / 477.5 m.
Spread type	:	Symmetric split spread.
Source / Charge size	:	Dynamite / 1.0 kg
Shot hole depth	:	17 m. to 24 m.

The high frequency geophone SM7 with natural frequency of 30Hz was used for conducting High Resolution

Seismic Survey. To compare the result of SM7 _30 Hz geophones with SM24_10Hz geophones, an additional spread of 192 channels with SM24_10Hz geophone was also used with same data acquisition parameters.

The characteristics of SM7_30Hz geophones & SM24_10 Hz geophones are listed below. SM7_30Hz SM24_10Hz

Resistance	:	370 ohm 375 ohm
Frequency	:	30 Hz 10 Hz
Damping	:	0.650 0.250
Sensitivity	:	12.8 V/m/s 28.8 V/m/s
Distortion	:	0.20 % 0.10 %
Spurious Freq.	:	500 Hz 240 Hz

Execution

1. The damages of crop were kept a minimum by strict monitoring of the shot hole pit size and asking the contractor to head load the drilling equipments and seismic ground electronics.

2. All the shot holes were drilled, properly washed and released by the contractor well in advance before the deployment of Ground electronics so that, the leakages in the cables, geophones and Station Units would be minimum.

3. Two identical lines one with SM24-10Hz geophones and other with SM7_30Hz geophones were laid side by side.

4. A every picket both type of geophones were planted in a single geophone pit of depth 1.5 feet.

5. Total line control was achieved by stopping all sources of cultural noises including movement of shooting crew during blasting. The Instrument Van was kept at about 300 m. perpendicular offset from the seismic line so that, the noise / vibrations due to instrument generator could be avoided.

6. Covering of geophone pits with plastic sheets and covering of cable connectors and Station Unit with plastic bags so that, mud water oozing out of the shot point after blasting did not come in contact with the ground electronics thereby minimizing the leakages.

7. Cross Station Unit as well as Instrument Van were shifted to take more no. of shots (due to limited channel capacity of CSU maximum 54 shots could be taken from one Instrument position).

8. Consistent good data quality was maintained with the help of check shots, analyzing the frequency spectrum of all the records in Mobile Processing Unit and taking preventive measures before hand.

9. While acquiring data on the dip line, a patch of hard formation was observed between Pkt No 224.5 and 342.5, where very hard rocks at a depth of one meter to three meters were encountered (not drillable even with URB rig). However after conducting experiments of blasting shot holes with different shot pattern and different distribution of charges, data was acquired with two hole pattern (properly tamped) with 0.5 Kg. charge in each hole. The quality of data in that patch was found to be well comparable.

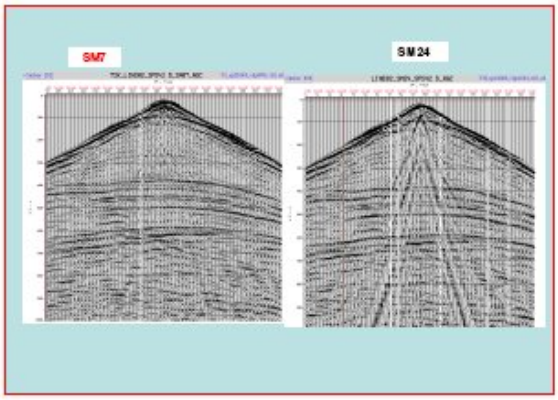

Figure 3: Raw plots with AGC

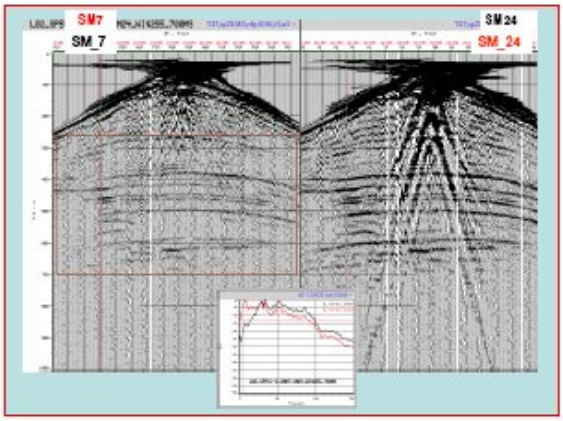

Figure 4: Raw plots without AGC & Freq. Spectrum

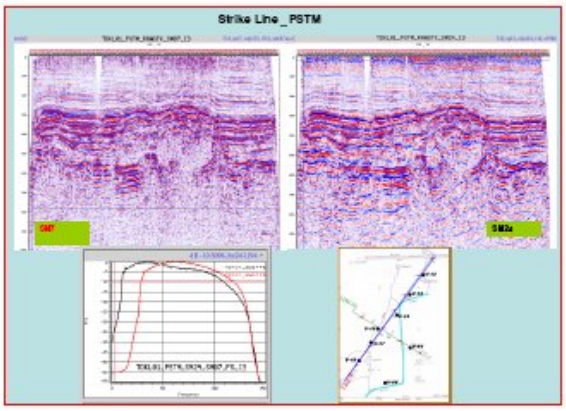

Figure 5: Strike line PSTM

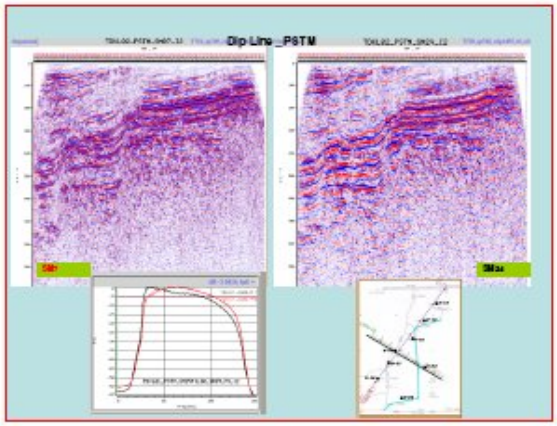

Figure 6: Dip line PSTM

Conclusion

The data acquired by two types of receivers was processed at RCC, Baroda and the output of both were compared at different stages of processing. The observations led to the inferences that for such type of surveys, high frequency geophones are more useful as their response for higher frequencies have less distortion and loaded more towards high frequency as compared to the low frequency geophones.

The processed sections for SM7_30Hz geophone of dip and strike lines show considerable high frequency bandwidth with the events clearly discernable in the zone of interest. The seismic sections also decipher some additional faults, which could not be mapped with the earlier existing 2D data. The fault pattern will certainly help in understanding the depositional pattern of coal seams in the area which in turn will help in future for designing UCG project.

Encouraged by the results of this experimental project with a very high quality data output , amenable for better imaging of subsurface for mapping the lignite and the faults, detailed High Resolution Seismic Survey with the same acquisition parameter for the complete Pilot Area has been planned for Underground Coal Gasification.