**_Image Enhancement through Common Reflection Surface Stack – Application to Seismic Reflection data of Mahanadi Basin and Delhi Aravalli Fold Belt_**

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***Summary***

We have applied Common Reflection Surface (CRS) stack to two different seismic data sets i.e. multifold seismic data of Mahanadi Basin to image the sedimentary environment and multi coverage deep seismic reflection data of Nagauar Jhalawar Geotransect in Delhi Aravalli Fold Belt to image the crust and sub crust region. Same data have been also processed using conventional data processing chain (CMP processing). In comparison with CMP stack, it has been observed that image has been greatly enhanced in CRS stack. Moreover as it makes use of seismic data from CMP direction as well as off CMP direction, better continuity of the reflectors and enhanced signal to noise(S/N) are achieved. These results show that CRS stack provides better image not only in sedimentary environment but also for the crust and sub crust region.

**Keywords**

Common Reflection Surface Stack, Mahanadi Basin, Delhi Aravalli fold belt.

**Introduction**

Common Mid Point (CMP) processing is a routine imaging technique in oil industries. However additionally we have used here Common Reflection Surface (CRS) stack as an alternative imaging technique to image the sub surface. This CRS stack is independent of velocity model and can stack the multi fold seismic data based on coherency analysis. Moreover, its stacking algorithm automatically corrects the effect of the dip and curvature of the reflector. Hence, Dip Move out (DMO) correction as a special processing is not necessary.

The Mahanadi basin, Orissa, is a deltaic type sedimentary basin of India. 2D seismic reflection data was acquired in Mahanadi Basin during 2003. Seismic data from this area has been reprocessed. Another set of data has been taken from 400 km long 2D multichannel deep seismic reflection data acquired by the National Geophysical Research Institute in the Delhi Aravalli fold belt. The results have been reported earlier (Tewari et al., 1997; Rajendra Prasad et al., 1999; and Rao et al., 2000). The aim of present study is to reprocess the seismic data using CRS stack and to improve the image quality. We have reprocessed the seismic data using both CMP stack and CRS stack method to see the improvement in the stack sections from shot point 2100 to 2900, which covers Mangalwar the complex from Nandsi to Jahazpur.

**The Common Reflection Surface stack method**

The CRS stack method is a multi parameter stacking to simulate zero offset stack section (Yoon et al., 2009). It describes kinematic multi coverage response of the common reflection surface instead of common reflection point. Thereby a stack section with improved signal to noise ration can be obtained.

The 2D CRS travel time formula is based on a hyperbolic second order Taylor expansion (Mann et al., 1999 and Yoon et al., 2009) is given by

$$t^2(x_m,h)=\left(t_0+\frac{2Sin\alpha}{v_0}(x_m-x_0)\right)^2+\frac{2t_0\cos^2\alpha}{v_0}\times\left(\frac{(x_m-x_0)^2}{R_N}+\frac{h^2}{R_{NIP}}\right) \qquad (1)$$

Where h the half offset between source and receiver, $x_m$ is the midpoint and $x_0$ is the location of the zero offset rays at the surface. Respective zero offset (ZO) section to which the equation (1) is to be applied is denoted by $P_0 = (x_0,\ t_0)$. Radius of curvature ($R_N$) of normal incidence point wave, radius of curvatures ($R_N$) of normal wave and emergence angle (α) are the CRS parameters or wave field attributes. They uniquely define the common reflection surface (CRS), i.e. its depth location, its curvature, its local dips and its multi coverage reflection response in an inhomogeneous medium in the vicinity of the CMP position $x_0$ (Yoon et al., 2009).

**Implementation**

In CRS stack our aim is to determine the simulated zero offset (ZO) section. In order to obtain the ZO section we have to determine three CRS parameters viz., the angle of emergence (α), radius of curvature of normal incidence point wave( $R_{NIP}$) and radius of curvature of normal wave($R_N$) for every sample $P(t_0,x_0)$ of the data. The appropriate CRS parameters can be obtained by performing coherency analysis (Tanner and Koehler, 1969). We have tested different parameters triplets to obtain better coherency along the respective stacking operator in the input data. Finally we have picked the stack section using the three parameters triplets which provides maximum coherency. Next the three parameter search is separated into three one parameter searche (Müller, 1999; Jäger et al., 2001) to find CRS attributes or CRS parameters. First so-called automatic CMP stack is performed which is equivalent to conventional normal moveout velocity ($V_{NMO}$) analysis and stack in CMP domain where,

$$v_{NMO}^2 = \frac{2V_0R_{NIP}}{V_0cos^2\ \alpha} \qquad (2)$$

This automatic CMP stack section is the preliminary result of ZO section which can be used to determine angle of emergence (α) using $R_N = \infty$, (i.e. plane wave approximation). $R_{NIP}$ can be determined with the help of α and $V_{NMO}$ using equation (2). To obtain $R_N$, we put h=0 in equation 1 and get the equation below.

$$t^2(x_m) = \left(t_0^2 + \frac{2\,Sin\alpha}{v_0}(x_m - x_0)\right)^2 + \frac{2t_0\cos^2\alpha}{v_0}\frac{\left(x_m - x_0\right)^2}{R_N} \tag{3}$$

With the help of α and $R_{NIP}$, determined earlier, we can now determine $R_N$ using equation (3). Final CRS stack is obtained inserting these three parameter triplets determined for each location P ($t_0$, $x_0$) into the 2D CRS stacking operator in equation (1). As the method is based on coherency analysis, multiples are also enhanced with coherent energy enhancement. These multiples can be eliminated by special corridor processing.

**CMP Data processing of seismic Data of Mahanadi basin**

2D seismic reflection data has been processed using Pro Max software. Format conversion from SEG D to SEG Y, bad race killing, top muting (Mute) has been done. Field geometry is applied and elevation correction is also done. After that, True Amplitude recovery (TAR) has been applied. Automatic gain control (AGC) of 500 window length and Band Pass filter with the band 10-12-40-60 hertz have been used to improve the signal and remove ground roll respectively. Trace mixing is also done to improve the signal. Predictive deconvolution has been performed to increase the resolution. Final stack section is represented in Fig.1.

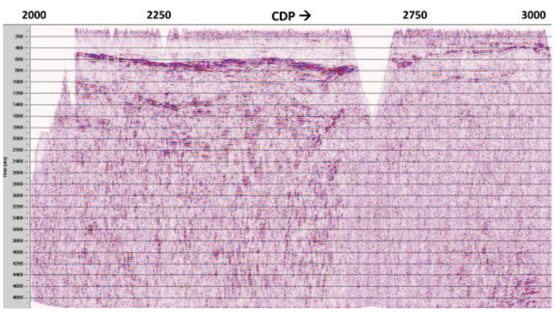


Fig.1. CMP Stack section of Mahanadi Basin

**CRS Stack**

CRS Stack has been generated using the same pre-conditioned and preprocessed gathers used for CMP stack. Near surface velocity $v_0$ = 1750 m/s is used. This $v_0$ acts as a kind of scaling factor connecting the travel time derivatives along the reflection events with their geometrical interpretation in terms of emergence angles and wave front curvatures i. e. the CRS attributes. Near-surface velocity which is roughly the RMS velocity for the most shallow stable reflection event has been chosen here. First automatic CMP stack section and coherency section have been obtained. Minimum and maximum stacking velocities for automatic CMP stack are 1800 m/s – 5000 m/s. Next zero offset (ZO) search is performed and CRS attributes are obtained. With these results final CRS stack is obtained (Fig. 2).

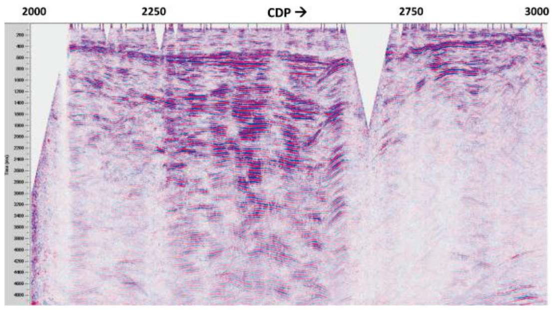


Fig.2. CRS stack section of Mahanadi Basin

**CMP Data processing of seismic data of Nagaur Jhalawar geotransect**

2D deep seismic reflection data was processed same way as mentioned above. Here band pass filter with frequency band 4-6-30-40 was used. After obtaining stack section, F-X deconvolution and coherency filter was applied to the stacked section to enhance the signal. Final stack section is represented in Fig. 3.

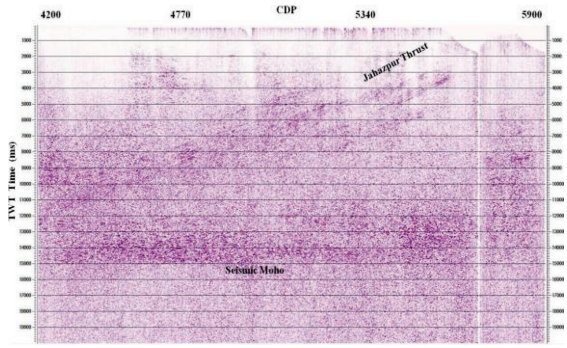


Fig.3 CMP Stack Section of Nagaur Jhalawar geotransect

**CRS Stack**

Same pre processed CMP data was taken as the CRS input. CRS stack is performed to the deep seismic data using near surface velocity $v_0$ = 2000 m/s. Minimum and maximum stacking velocity for automatic CMP stack are 5000 m/s – 8500 m/s respectively . Final optimized CRS stack was same way as mentioned earlier (Fig. 4).

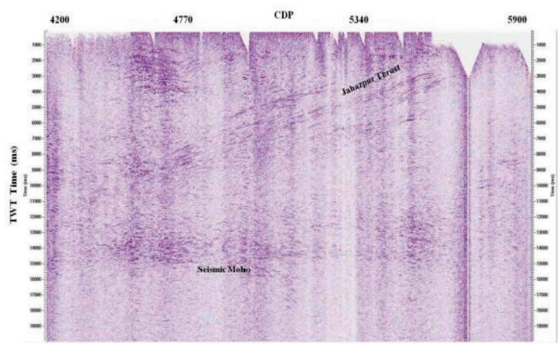


Fig.4. CRS Stack Section of Nagaur Jhalawar geotransect

**Conclusions**

The reprocessing of the seismic reflection data from Mahanadi Basin and Naugar Jhalawar geo transects yield improved seismic images. The comparison with the results obtained from conventional seismic processing shows that processing with CRS stack provides improved signal to noise ratio and better continuity of the reflectors. The Jahazpur thrust and Seismic Moho and at a depth of 14 s (TWT) is clear in both the CMP stack and CRS stack section but much more distinct in CRS stack section in Nagaur Jhalawar geotransect. Shallow reflections in the Nagaur Jhalawar geotransect are very distinct in the CRS stack which is not visible in the image obtained by conventional processing software. Hence it is clear that CRS stack provides improved image in sedimentary environment as well as deep seismic imaging of the crust.

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