Abstract

To characterize the reservoir, seismic inversion methods have been frequently used for estimating attributes like Elastic Impedance, P-impedance, S-impedance, Density, V_P/V_S ratio and gamma ray logs from seismic and well log data. These attributes allow us to understand subsurface lithology for geo-seismic analysis, its extent and shape etc. The purpose of this research is to compare various seismic post- and pre-stack inversion methods from the seismic and well log data tie-ups. Furthermore, state-of-art geostatistical techniques have also been used intensively for further testifying the results obtained from post-stack inversion methods.

In this research, four types of post-stack inversion methods, namely, bandlimited inversion (BLI), colored inversion (CI), maximum likelihood sparse spike inversion (MLSSI) and model based inversion (MBI) methods have been performed to the post-stack seismic data from the F3 block, the Netherlands. For the pre-stack inversion, namely, simultaneous inversion (SI), lambda-mu-rho (LMR) transform and elastic impedance inversion (EI) have been applied on the seismic data of the Penobscot region, Canada. Using post-stack inversion, the data was inverted into P-impedance. The final inverted P-impedance section derived from post-stack inversion methods displayed high-resolution images within the two-way travel time range of 1300 to 1800ms time intervals. This has revealed mutually reliable low impedances results (at 1700ms time interval).

The use of SI was done for the computation of compressional and shear-wave impedances (Z_P and Z_S), V_P/V_S ratio and Lambda-Mu- Rho (LMR) attributes and their extraction. The results have suggested absence of any major reservoirs present in the Penobscot region. Data conditioning was performed to evaluate its impact on SI and LMR transform derived results.

The elastic impedance inversion was also employed to estimate subsurface elastic properties in the inter well region. These elastic properties assist in identifying gas-bearing formation from gas free formation, as well as overpressure zones. Seismic reflection data from the Penobscot region, were used for the analysis, which was performed in two steps. Initially, the method was tested with zero Gaussian noise level on synthetic data and subsequently with incremental levels of 10% 20% and 30% Gaussian noise levels. The analysis shows that efficacy of elastic impedance inversion decreases only by 3.5% with addition of Gaussian noise levels even up to 30% in the data compared to zero Gaussian noise level. Hence, it may be assumed that Gaussian noise does not make highly significant changes in the EI values.

In the second step, EI was applied to the real time data and variation of was estimated for near and far-angle stack gathers. The analysis demonstrates that the inverted results follow the well log results satisfactorily. The results also revealed higher resolution images for the far-angle stack data compared to the near-angle stack data. Therefore, it may be assumed to be fairly established that the pre-stack data of Penobscot region does not contain any major gas or overpressure zones.

Four types of geostatistical techniques: single attribute analysis, multi attribute analysis, probabilistic neural network, and multilayer feed forward network methods have been also used to predict volumes of various petrophysical parameters (porosity, density, P-wave, and gamma ray) within the F3 block post-stack data. In these techniques, seismic and well log data derived attributes have been used as an internal attribute while model based inversion derived impedance has been used as an external attribute. Firstly, single attribute analysis has been performed which could not provide consistent result. Thereafter, multi attribute analysis was performed.

Subsequently, from the estimates, the predicted logs derived from multi attribute analysis technique show correlation values of 0.95, 0.94, 0.93 and 0.79 for porosity, density, P-wave and gamma ray, respectively. Probabilistic neural network and multilayer feed forward network analysis have been performed using model based inversion results as as an external attributes. The correlation coefficient derived from probabilistic neural network is 0.97, 0.96, 0.95, and 0.82 for porosity, density, P-wave and gamma ray, respectively. The correlation coefficient derived from multilayer feed forward network is 0.96, 0.95, 0.94, and 0.86 for porosity, density, P-wave and gamma ray, respectively. From these four geostatistical techniques, probabilistic neural network method seems to slightly better correlation coefficient than multi attribute analysis. However, PNN and MLFN could be considered as yielding almost identical results.

In summary, the aforesaid post-stack inversion methods have yielded fairly accurate and reliable results and unequivocally confirm the presence of reservoir (at 1700ms time interval).

Pre-stack method suffers from the limited band-width of the seismic data as well as from paucity of well-log data. No reservoir was detected within the pre-stack data after applying all the pre-stack inversion methods.

The reservoir properties have been better estimated with probabilistic neural network in comparison to multi attribute analysis and multilayer feed forward neural network. The results are illustrated in form of tables, graphs and images etc. and have been discussed separately to draw the conclusions.