Scholars Bulletin
(A Multidisciplinary Journal)
An Official Publication of "Scholars Middle East Publishers",
Dubai, United Arab Emirates
Website: http://scholarsbulletin.com/

ISSN 2412-9771 (Print)
ISSN 2412-897X (Online)

The review of seismic Full waveform inversion

Lin Yujia
Earth Science of Northeast Petroleum University, Daqing- 163318, P.R. China.

***Corresponding Author:**
Lin Yujia
Email: 1624562760@qq.com

Abstract: In recent years, seismic waveform inversion, which has attracted wide attention, has greatly contributed to the development of seismic prospecting. Thus, it is of tremendous significance to do further research about seismic wave form inversion. Firstly, the early stage of its development is introduced. Secondly, the seismic waveform inversion is discussed through theories, methods and numerical settings. Finally, a review on the selection of model, inversion methods and the applications of regularization is given.
Keywords: seismic waveform inversion; visco-elastic medium; regularization methods; time domain and frequency domain.

INTRODUCTIONS

The past century, geophysics has been rapid development, especially in seismic waves to study the background of seismic exploration technology for the development of energy, and exploration of underground structures create favorable conditions. Seismic exploration theory has been refined, high-tech are constantly being introduced and applied. Seismic exploration ground-based data can be explained by the seismic waveform inversion solving, and seismic waveform inversion can be obtained using different numerical methods. To the desired physical parameters, in recent years, with the gradual cross-observation technology, information science, applied mathematics and computer science, physicist, Number Scientists, geologists and engineers work closely, making seismic wave form inversion of seismic exploration in deeper and deeper. However, Due to the continuous development of resources caused by narrowing the scope of exploration as well as exploration targets the growing complexity of seismic waveform inversion research and application of case work, the enormous difficulties and challenges. Therefore, the study and a wide range of practical and reliable convergence of seismic waveform inversion numerical method have great theoretical and practical significance.

The ultimate goal of seismic exploration is to locate the underground distribution of oil and gas resources, the general practice is on the ground artificial excitation of seismic waves, since the non-uniformity of the medium, when the media spread through in formation medium all directions, it will produce reflection, diffraction, scattering and transmission, seismic wave component is returned to ground face constitutes a seismic data received. The main seismic exploration work is extracted from these observations in the stratigraphic section and the medium was parameters, and to determine the location of oil and gas reservoirs. Research work in a variety of commonly used elastic wave equation to describe the dynamics of the seismic waves in the ground media communication process. Seismic data can be modeled by a wave equation forward modeling, seismic waveform inversion can then be used to reconstruct the sectional formation surface and physical parameters. Although seismic waveform inversion research is still in its infancy, but the huge economic benefits and broad application background makes near the hot phase inversion theory and practical application.

SEISMIC WAVEFORM INVERSION PROCESS

In the 1980s, seismic waveform inversion linear waveform inversion based. Lailly [1], Tarantola [2], Berkhout [3], Devaney [4], Respectively, linear seismic waveform inversion done some preliminary research, Lailly [1] and Tarantola [5] for the seismic waveform inversion shows a configuration Gradient direction (or the direction of steepest descent) without direct method to calculate partial derivatives. In this method, the associated seismic source generated by the forward propagation wave field and wave field generated by the remaining data to construct backward propagation direction of the gradient. Since each step iteration inversion in just a few forward for each seismic source, which makes seismic waveform inversion in the 1980s possible? However, we can not solve the linear inversion of seismic wave velocity model long-wavelength components of the problem, Devaney noted that linear seismic waveform inversion can not restore the long-wave field components of the velocity field, and Mora [6] also proved in exploration normal conditions, only a fully nonlinear seismic waveform inversion can be observed all the seismic wave field wave velocity field pointsthe amount. Mora [7], Pica [8], etc., Tarantola [9] and others on a fully nonlinear waveform inversion were studied in detail, and strive to decrease by an iterative method, Seek the objective function minimum velocity model. Pratt [10-11] et al, respectively, in the frequency domain will be applied fully nonlinear elastic and acoustic Question. However, due to the large number of local minima and the inversion results unsatisfactory. In order to overcome local optima problem, many solutions law. For nonlinear seismic wave form inversion proposed simulated annealing method, simulated annealing method does not require a good initial model, and will not fall into local minima. Bunks [13], who proposed a multi-grid scale decomposition method, multigrid method they use seismic data decomposition on different scales, according to the scale decomposition thoughts iterative inversion for complex geological model experiments were made to obtain good results. Zhou Hui [14] et al. studied the global objective function can obtain optimal genetic algorithm to train the artificial neural network approach and proposes accelerated network close convergence approach. Hong Ying Meng [15] et al. proposed a multi-scale wavelet transform, one-dimensional model of the spreadsheet, and simple iterative method and existing and multigrid method were compared, the results show better. But the disadvantage of the above method is a relatively large amount of calculation.

RESEARCH PROGRESS

In recent years, many scholars and different backgrounds and different ways of doing inversion depth research. Yuan Shujin [16] For pre-stack seismic inversion application of lithologic reservoir exploration discussed elastic impedance inversion, wave impedance inversion of pre-stack P and S wave impedance inversion and prestack seismic waveform transplay. Supposing the seismic wave propagation follows the constant density acoustic wave equation, and to optimize the use of nonlinear seismic waveform based on this basis inversion method. To overcome the problem of local minima are discussed and simulated annealing genetic algorithm feasibility and advantages and disadvantages and further pointed out that in recent years. Developed multi-scale (multi-resolution) inversion method in searching the global minimum point, the inversion of the advantages of stability and convergence rate.

Sheen [17] et al. for an elastic medium seismic waveform inversion time domain Gauss-Newton method, using velocity-stress staggered grid finite difference points system and PML absorbing boundary condition as a wave equation, and apply the reciprocity principle and avoid explicit convolution theorem to calculate Jacobi matrix and the Hessian. To reduce the amount of computation and memory requirements of the computer, in space and time domain using a different scale to the grid Wave form inversion and approximate virtual source. In the numerical experiment which gives the Gauss-Newton can be seen in terms of law in regard to anti-gradient method Play better.

Symes [18] will link migration velocity analysis and waveform inversion problem, pointing migration velocity analysis is in fact solving the problem waveform inversion unit. A method of sub-linear deformation of contact between the conceptual model is an extension of, and based on this model can be extended by the wave field non-physical model depends on redundant data. Symes further noted that both the guide data based on the surface and depth guide data (wave equation) offsets Deformation velocity analysis can be extended at an appropriate model is equivalent to the waveform inversion.

Vigh and Starr [19] discussed the 3-d prestack plane wave full waveform inversion method of steepest descent. This paper USES the acoustic wave equation, the reverse Like and apply the formula in speed

$$\rho = \rho_0 V^{k_0} \quad (1)$$

$(\rho_0 = 0.31g / cm^3, k_0 = 0.25)$ associating density and velocity. Calculate the optimal linear search step in applying the steepest descent method. In Numerical simulation, Vigh and Starr application of this method in the Gulf of Mexico, data processing and data SMAART Pluto 1. 5.

Rastogi [20] et al. for seismic full waveform inversion method forward reflectivity, reflectivity versus a finite difference based on the elastic wave equation. Method is more efficient, and easier to calculate the level of solutions for layered geological model of wave field. This paper uses in the oil and gas industry applications with more amplitude. Azimuthal variation (AVA) inversion method and a combination of genetic algorithm to solve it.

In the development of undersea earthquakes, often we face are elastic composite acoustic environment. Since the application of undersea cables and geophones, can be obtained, Land seismic develop the same multi-component data. Choi [21] et al. two-dimensional acoustic wave elastic composite dielectric multi-component data inversion problem in the frequency domain. The application of the finite element method forward and apply the correction gradient direction of the conjugate gradient method inversion. Choi and other frequency-domain inversion can be noted in the mold Pseudo multichannel excitation source is more effective, and easy to introduce back-propagation algorithm.

For large-scale three-dimensional elastic full waveform inversion problem, Epanomeritakis [22] et al. combined with the outer layer of the Gauss-Newton nonlinear iteration within layer linear conjugate gradient iteration method makes use Armijo linear search of global solved on the fine grid and high frequency and thus is an iterative sequence protection. Held in the near global optimum application of total variation (TV) regularization inversion mutation to the edge region, by the finite element method Lamé parameters from space Scattered to avoid bias, thereby eliminating the use of adjoint method to calculate the gradient and Hessian matrix, and multiple scales continuation method iterators maintained at the global optimum convergence domain values.

Hu [23] et al. for simultaneous multi-frequency full waveform inversion of seismic data, the application of Gauss-Newton method to ensure a high rate of convergence of the method and reconstructed exactly like speed. Accompanied by the introduction of the modified formula can be more efficient computing Jacobi matrix, and so perfectly matched layer (PML) in physical properties can be automatically update in the inversion process. The paper noted that when using a lot of sources, frequency domain method is relatively more advantageous. This is because, at least two, Dimensional imaging, multi-source forward solving avoid redundant calculations. It uses two regularization methods: L2, and weighted L2 norm, norm regularization, and points, do not use this method to smooth edges of the cross-sectional and sectional mutation.

MODEL SELECTION

Researchers generally discuss the seismic wave propagation theory; the seismic waves are mostly seen as elastic waves. Although the time in simulated seismic wave propagation, playing media model is the most widely used, but in fact no single medium is ideal perfectly elastic body, while the viscoelastic medium is more connected than the elastic medium near the actual formation media. Seismic wave propagation in real stratum medium and spread over the medium is not the same, the real medium viscosity will gradually seismic wave energy loss, and so continue to decay amplitude fluctuation frequency decreased. Since the real attenuation and dispersion of seismic waves, not from seismic data directly for detailed subsurface physical parameters and higher resolution stratigraphic section. In the forward modeling, inversion and arguments over Reconstruction Process should not affect the propagation of seismic waves in the process right, so on the basis of seismic waves pass viscoelastic medium viscosity media ignored Sowing and seismic waveform inversion has important significance.

In recent years, many scholars in-depth study of the viscoelastic medium seismic wave field simulation and research viscoelastic medium is still in seismic waveform inversion. Infancy Yang and Qian [24] applied wavelet transform to obtain three-dimensional exact solutions of viscoelastic wave equation inversion, and then presents the results of the past like expression. Single Kai copper [25] compared the difference between pseudo-spectral method and finite difference method to simulate viscoelastic medium wave field propagation time, and genetic algorithm and mold simulated annealing algorithm combines nonlinear inversion problem to deal with viscoelastic medium parameters. Tian Ying chun [26], etc. for the parameters of two-phase viscoelastic medium inversion problem shows the corresponding nonlinear functional global minimum problem, and a wide range of homotopy method will be applied to solve the global convergence of the minimal functional value and as a counter question final solution.

CONCLUSION

For seismic waveform inversion problem, time domain and frequency domain methods in dealing with problems in different situations have advantages and disadvantages, which can be seen in the inversion method up to now is widely used is the Gauss-Newton method, Newton-type method, gradient descent algorithm (steepest descent method) and the conjugate gradient method, and in the real regularization method used in international projects regularization method is not as abundant as in the development of theory, so the existing regularization theory. In practice, to give a more stable and accurate inversion algorithm is necessary. In addition, studies closer to the real situation of the actual exploration model can work. For better inversion results, so the inversion has more important theoretical significance and application value based on seismic waveform complex media model.

REFERENCES

1. Lailly, P. (1983). The seismic inverse problem as a sequence of before stack migrations. In *Conference on inverse scattering: theory and application* (pp. 206-220). Society for Industrial and Applied Mathematics, Philadelphia, PA.
2. Tarantola, A. (1984). Linearized inversion of seismic reflection data. *Geophysical prospecting*, *32*(6), 998-1015.
3. Berkhout, A. J. (1984). Multidimensional linearized inversion and seismic migration. *Geophysics*, *49*(11), 1881-1895.
4. Devaney, A. J. (1984). Geophysical diffraction tomography. *Geoscience and Remote Sensing, IEEE Transactions on*, (1), 3-13.
5. Tarantola, A. (1984). Inversion of seismic reflection data in the acoustic approximation. *Geophysics*, *49*(8), 1259-1266.
6. Mora, P. (1989). Inversion= migration+ tomography. In *Parallel Computing 1988* (pp. 78-101). Springer Berlin Heidelberg.
7. Mora, P. (1987). Nonlinear two-dimensional elastic inversion of multioffset seismic data. *Geophysics*, *52*(9), 1211-1228.

8. Pica, A., Diet, J. P., & Tarantola, A. (1990). Nonlinear inversion of seismic reflection data in a laterally invariant medium. *Geophysics*, *55*(3), 284-292.
9. Tarantola, A. (1986). A strategy for nonlinear elastic inversion of seismic reflection data. *Geophysics*, *51*(10), 1893-1903.
10. Pratt, R. G. (1990). Inverse Theory Applied To Multi-Source Cross-Hole Tomography. *Geophysical Prospecting*, *38*(3), 311-329.
11. Pratt, R. G., Shin, C., & Hick, G. J. (1998). Gauss–Newton and full Newton methods in frequency–space seismic waveform inversion. *Geophysical Journal International*, *133*(2), 341-362.
12. Sen, M. K., & Stoffa, P. L. (1991). Nonlinear one-dimensional seismic waveform inversion using simulated annealing. *Geophysics*, *56*(10), 1624-1638.
13. Bunks, C., Saleck, F. M., Zaleski, S., & Chavent, G. (1995). Multiscale seismic waveform inversion. *Geophysics*, *60*(5), 1457-1473.
14. Zhou., H., Teng., H.Q., & Xu., Z. (1997). Artificial neural network nonlinear seismic waveform inversion [J]. Petroleum Geophysical Prospecting, 36(1), 61-70
15. Meng., H., Y., & Liu., G. (1999). Wavelet transform multiscale seismic waveform inversion. Chinese Journal of Geophysics, 42(2), 241-248.
16. Court book gold. (2007). Advances in technology stack seismic inversion and its application in lithologic reservoir exploration. Chinese Journal of Geophysics, 22, 879-886.
17. Sheen, D. H., Tuncay, K., Baag, C. E., & Ortoleva, P. J. (2006). Time domain Gauss—Newton seismic waveform inversion in elastic media. *Geophysical Journal International*, *167*(3), 1373-1384.
18. Symes, W. W. (2008). Migration velocity analysis and waveform inversion. *Geophysical prospecting*, *56*(6), 765-790.
19. Vigh, D., & Starr, E. W. (2008). 3D prestack plane-wave, full-waveform inversion. *Geophysics*, *73*(5), VE135-VE144.
20. Rastogi., R., Srivastava., A., & Shirodkar., K, (2008).. Seismic full waveform inversion and modeling [C]. 7th International Conference & Exposition on Petroleum Geophysics. Hyderabad, 2008.
21. Choi, Y., Min, D. J., & Shin, C. (2008). Two-dimensional waveform inversion of multi-component data in acoustic-elastic coupled media. *Geophysical prospecting*, *56*(6), 863-881.
22. Epanomeritakis, I., Akçelik, V., Ghattas, O., & Bielak, J. (2008). A Newton-CG method for large-scale three-dimensional elastic full-waveform seismic inversion. *Inverse Problems*, *24*(3), 034015.
23. Hu, W., Abubakar, A., & Habashy, T. M. (2009). Simultaneous multifrequency inversion of full-waveform seismic data. *Geophysics*, *74*(2), R1-R14.
24. Yang, F., & Qian, S. (1994). 3-D viscoelastic wave equation inversion: Application of wavelet transform. *64th Ann. Internat. Mtg: Soc. of Expl. Geophys*, 1046-1048.
25. Copper single start. (2007). Viscoelastic wave equation forward modeling and inversion parameter [D]. Beijing: China University of Petroleum, 13-44.
26. Tian., Y., Zhang., Zi., Mao., M., & Jian., W. (2009). Homotopy method viscoelastic parameters of two-phase medium inversion. 52 (9), 2328-2334.