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A NEW INVERSION METHOD OF TIME-LAPSE SEISMIC*

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Abstract *Time-Lapse Seismic improves oil recovery ratio by dynamic reservoir monitoring. Because of the large number of seismic explorations in the process of time-lapse seismic inversion, traditional methods need plenty of inversion calculations which cost high computational works. The method is therefore inefficient. In this paper, in order to reduce the repeating computations in traditional, a new time-lapse seismic inversion method is put forward. Firstly a homotopy-regularization method is proposed for the first time inversion. Secondly, with the first time inversion results as the initial value of following model, a model of the second time inversion is rebuilt by analyzing the characters of time-lapse seismic and localized inversion method is designed by using the model. Finally, through simulation, the comparison between traditional method and the new scheme is given. Our simulation results show that the new scheme could save the algorithm computations greatly.*

Key words *Time-Lapse Seismic; homotopy-regularization method; localized inversion method.*

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1 Introduction

Time-lapse seismic method makes seismic exploration development from the static reservoir description to the dynamic monitoring. The concept of the space-time is introduced into the reservoir exploitation which changes the fundamental conception of oil field production. Time-lapse seismic consists of two or more seismic surveys shots at different calendar times. The purpose of time-lapse seismic measurements is to monitor the reservoir during the production by detecting production induced changes in the seismic parameters[1,2]. Assuming seismic repeatability, these changes can be translated into some changes in the reservoir properties, i.e. pressure

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and fluid properties. While interpreting the time-lapse seismic measurements, it is assumed that the geological setting is unchanged. Moreover the time between the base and monitor survey is negligible compared to the geological time scale.

The key ides of the data processing of time-lapse seismic is to identify the change of the reservoir properties from minor changes in the data. In the time-lapse seismic forward problem, a finite-difference injection method is designed by Robertsson[3,4]. In order to avoid calculating Green function, an improved finite-difference injection method is proposed by Han Bo[5].

In the inversion of the time-lapse seismic, Abubakar[6] and Gluck[7] discussed the feasibility of impedance inversion respectively. Herawati[8] used a constrained sparse-spike algorithm to calculate the P-wave impedance inversion. Minkoff[9] used some coupled models of fluid flow and mechanical deformation to accurately predict production in compactible reservoirs. Leary[10] studied the first-order backscattered P-wave and S-wave for time-lapse seismic imaging in heterogeneous reservoirs.

Generally speaking, the time-lapse seismic is a new technique of monitoring the reservoir. Its theories and numerical methods are yet perfect, especially in the research of inversion. In this paper, a new widely converged homotopy-regularization method is designed, and it is used as inversion method for the first inversion method. Furthermore it also provides good initial estimates for the second time seismic. By analyzing the characters of time-lapse seismic, we rebuild a model for the second time inversion. Finally, a localized method based on the resulting model and the Gauss-Newton method is proposed.

2 Homotopy-regularization method

We consider the heterogeneous elastic isotropy medium and use the acoustic wave equation to approximate the elastic wave equation. This simple model is sufficient to research its primary character. The acoustic wave equation is given as

$$\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial z^2}-\frac{1}{v^2(x,z)}\frac{\partial^2 u}{\partial t^2}=s(t)\delta(x,z),\ t>0, \tag{1}$$

where $\delta(x,z)$ is the Dirac-δ function, $v(x,z)$ is the velocity at (x,z) in the medium, $s(t)$ is a source time function such that $s(t)=0, t<0$, and (x,z) is the horizontal and vertical coordinates, respectively. t is the coordinate in time. Assume that the problem is in the field of $\Omega=[0,L]\times[0,H]$ and Clayton absorbing boundary[11] condition are imposed

$$\left(\frac{\partial^2 u}{\partial x\partial t}+\frac{1}{v(x,z)}\frac{\partial^2 u}{\partial t^2}-\frac{v(x,z)}{2}\frac{\partial^2 u}{\partial z^2}\right)\bigg|_{x=L}=0, \tag{2}$$

$$\left(\frac{\partial^2 u}{\partial x\partial t}+\frac{1}{v(x,z)}\frac{\partial^2 u}{\partial t^2}-\frac{v(x,z)}{2}\frac{\partial^2 u}{\partial z^2}\right)\bigg|_{x=0}=0, \tag{3}$$