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NUMERICAL SIMULATION AND ANALYSIS OF MIGRATION-ACCUMULATION OF OIL RESOURCES

YIRANG YUAN

Abstract. Numerical simulation of migration-accumulation of oil resources in porous media is to describe the history of oil migration and accumulation in basin evolution. It is of great value to the evaluation of oil resources and to the determination of the location and amount of oil deposits. This thesis puts forward a mathematical model, a careful parallel operator splitting-up implicit iterative scheme, parallel arithmetic program, parallel arithmetic information and alternating-direction mesh subdivision. For the actual situation of Tanhai region of Shengli Petroleum Field, our numerical simulation test results and the actual conditions are coincident. For the model problem (nonlinear coupled system) optimal order estimates in l^2 norm are derived to determine the errors. We have successfully solved the difficult problem in the fields of permeation fluid mechanics and petroleum geology.

Key Words. migration-accumulation of oil resources; multilayer parallel arithmetic; careful numerical simulation, l^2 error estimates.

1. Introduction

The oil formation in sediment basins, its displacement, transport and accumulation, and the final formation of oil deposits have been one of the key problems in the exploration of oil-gas resources. How has oil been accumulated in the present loop according to the mechanics of immiscible flow? How is oil distributed in basins? All this is what the numerical simulation of accumulation of oil resources mainly studies[1−5]. With the exploration of the oilfields, efforts have been made to find covered and "potato piece" oil deposits, so basin simulation must be more and more precise become large-scale and develop in parallel direction. In basin simulation, the migration-accumulation of oil resources in particular, the traditional serial computers can hardly solve this problem[4−6].

The fluid dynamics model of migration-accumulation has strong hyperbolic characteristics. Therefore, the numerical method is very difficult in mathematics and mechanics. In this field, Ungerer, P., Walte, D. H., Yukler, M. A. and others have had famous publications[7−9]. They have studied the mathematical model and numerical simulation of the two-dimensional section, which have found their practical application in North Sea Oil Field. In China, Wang Jie, Cha Ming and others have also done important jobs[4,10] centered on petroleum geology. In a word, first fruits in monolayer problems have reaped [4,11−14]. This thesis, from the actual conditions

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and for highly accurate and careful parallel numerical simulation of oil resources migration-accumulation, we put forward a mathematical model and a careful parallel operator splitting-up implicit iterative scheme, parallel arithmetic program, parallel arithmetic information transmission and alternating-direction mesh subdivision. Making use of the present SGI high-performance miniature computer group (8CPU), we have conducted parallel arithmetic of the "careful numerical simulation of migration-accumulation of oil resources". We have made parallel computation and analysis of four schemes, namely, the mesh step lengths are 800m., 400m., 200m., and 100m. Our results are identical with the actual situation. For the model problem (nonlinear coupled system) optimal order estimates in l^2 norm are derived to determine the errors. We have successfully solved the difficult problem in the fields of permeation fluid mechanics and petroleum geology. This thesis discusses the numerical simulation of the migration-accumulation of oil resources, the most difficult part in basin simulation and important in rational evaluation of oil resources and exploration oil deposit locations.

2. The Mathematical Model

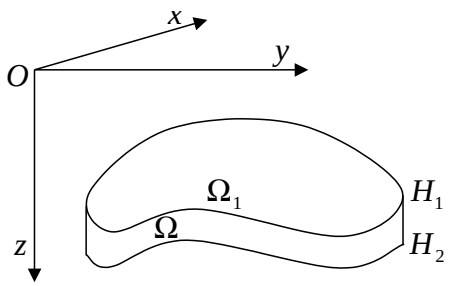

Fig. 1 two-layer sketch map of regions Ω, Ω_1

The mechanism of migration-accumulation of oil resources:

The primary driving force of migration-accumulation is the buoyancy caused by both the density difference between the oil in the carrying bed and that of the water in the porous structure, and the potential gradient formed by all the fluid (water and oil) in the porous structure, while the fluid is trying to migrate to the low-potential area.

The restricting force of migration-accumulation has something to do with the capillary pressure which gets larger while the aperture becomes narrower. If the capillary pressure exceeds the driving force, the migration will be held up. The migration of oil and underground water is mainly a permeation process. Both the oil and water potential fields determine the direction and magnitude of oil and water permeations.

For the numerical simulation of secondary multilayer oil migration in porous media, the flow in the first and third layers is considered as horizontal and in the one between them as vertical. After careful analysis of the model and the scientific numerical test, we propose a creative and rational numerical model. For the mathematical model of multilayer migration-accumulation:

$$\begin{gathered}\nabla\cdot(K_1\frac{k_{ro}}{\mu_o}\nabla\psi_o)+B_oq-(K_3\frac{k_{ro}}{\mu_0}\frac{\partial\psi_0}{\partial z})_{z=H_1}=-\Phi s'(\frac{\partial\psi_0}{\partial t}-\frac{\partial\psi_w}{\partial t}),\\ X=(x,\ y)^T\in\Omega_1,\ t\in J=(0,\ T],\end{gathered}\tag{1a}$$