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A 3-D geological modeling method and its application to petroleum migration and accumulation simulation

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Besides the carrier bed, faults and unconformities are important migration pathways for the 3-D petroleum migration and accumulation simulation. The fault is often ignored or used only as simulated grid boundaries in the traditional 3-D geological modeling, so that the transport function of faults is neglected or weakened.

In view of the fact that the traditional geological modeling method cannot establish the interrelation of carrier-system (the carrier bed, fault, unconformity, etc.), we propose a hybrid-dimensional mesh modeling technology consisting of body (stratum), surfaces (faults and unconformities), lines and points. The stratum mesh cut by a fault consists of stratum body A, stratum body B and fault surface C. There are two methods: (1) The fault is neglected in the modeling of the geological body, in other words, the mesh form and volume remain unchanged; and (2) The fault is considered in the modeling of the geological body, and the geological body on the two sides of the fault are divided into two parts for modeling. We propose the third processing method. The fault is considered in the modeling of the geological body, and the geological bodies on the two sides of the fault are divided into two parts for modeling, forming stratum meshes. In addition, the fault surface is taken as the third mesh, i.e. surface mesh. At this point, the mesh system is not the original single stratum mesh (3D body mesh) any more, and it also contains the surface mesh (2D surface mesh), therefore it is called a hybrid-dimensional mesh system (hybrid mesh system).

Based on new hybrid-dimensional mesh of the carrier-system, a special 3-D invasion percolation model (3-DIP) is proposed. The fault transport ability can also be determined by shale gouge ratio (SGR) in the 3-DIP model.

The new method is applied to the Luliang uplift in Junggar Basin, China, with an area of 3502 km^2. The strata are composed of Permian - Cretaceous, which are divided into 15 simulated layers. Key simulation parameters of the study area include 2884 plane simulation meshes, 59 faults and 1 unconformity. The total number of formed meshes is 54406, including 45972 body meshes, 7884 surface meshes, 549 line meshes and 1 point mesh.

The migration pathway of oil is traced by 3-DIP, and the oil accumulation and wax content of crude oil are simulated. By comparing the simulated wax content with the measured wax content, the results are consistent with each other. It is shown that the model is reliable and the results are

credible.

Key words: geological modeling, migration pathway, hybrid mesh, invasion percolation model, petroleum migration and accumulation simulation, Junggar Basin.