AAPG International Conference: October 24-27, 2004; Cancun, Mexico

Application of 4-D Petroleum System Analysis to the Northeastern Deep Gulf of Mexico

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A new suite of software for the modelling of petroleum systems in three-dimensions and through time has been developed and comprises four modules: a 3-D model builder, a 3-D structural restoration program (Struct 3-D), a 3-D pressure-temperature simulator (SIM), and a 3-D multiphase migration program (GEM). The model builder is used to construct 3-D models based on geological time surfaces and faults. Struct 3-D carries out geometrical restorations through retro-deformation of fault movements coupled with Athy-type decompaction through time. SIM calculates 3-D differential pressure, temperature, and porosity evolution using finite element modelling. Iteration between Struct 3-D and SIM at each time step ensures optimized restored and decompacted geometries of time surfaces back through geological time: this is a newly developed technique called “Restoration Inversion”. A complete set of retro-deformation models is stored and run forward through geological time for the purposes of modelling the hydrocarbon migration using GEM.

This suite of software has been used to model the petroleum system in an area of the Northeastern Deep Gulf of Mexico. Closely spaced 2-D seismic lines permitted the construction of a 3-D earth model. The modelled area is dominated by extensional tectonics and multi-level allochthonous salt systems and lies north of the NE-SW trending Mississippi fold belt. In order to perform 4-D modelling, the extensional fault system has been retro-deformed and salt breakouts plus reactive and active diapirs have been removed using 3-D volume restoration techniques.