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Finite Element Modeling of Inversion Tectonics: Application to the Elgin-Franklin Field, North Sea

Finite element (FE) modeling is a powerful tool for understanding the evolution of geologic structures. While FE applications are common in engineering disciplines, the adoption has been slower since geologic problems are often more complex, and the generation and interpretation of FE models requires skills beyond those normally taught to geologists. Despite these difficulties, the FE method offers a significant advantage in geology since the complete history (displacements, stresses, strains and pore pressure) can be obtained while employing more realistic physical and mechanical material properties and loads. We present results of a study that focuses on the structural/tectonic development of a North Sea field and demonstrate the utility that this modeling offers for understanding reservoir development in areas with complex histories.

The primary goals were to generate realistic two-dimensional models of the stress/strain history and likely locations of secondary faulting during extension and subsequent inversion of a listric fault, and to include effects from syn-tectonic deposition and subsidence. Based on the Elgin-Franklin field in the central North Sea, our simulation focuses on the hanging wall region that undergoes 5 km of extension along a listric fault, ''syn-tectonic'' sedimentation, and finally 8 km of inversion. Initial efforts use relatively simple material models and loads, but work is expanding to include more realistic rock characteristics (porosity, permeability, fluid saturation, and temperature) and constitutive models (e.g., poroelastic or poroelastoplastic). Ultimately, we expect to offer a three-dimensional simulation that incorporates available data and yields all the components that might be required for the drilling/development and exploitation of an oil and gas field.