Numerical modeling of CO_2 injection into a typical U.S. Gulf Coast anticline structure

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Abstract:

This paper summarizes recent numerical modeling activities investigating geological CO2 sequestration project at the Cranfield field, Mississippi, USA, performed with the commercial compositional flow simulator CMG-GEM. The oilfield was produced from the 1940's to the 1960's but has been the recent recipient of an enhanced oil recovery (EOR) CO2 flood. The subset of actual site operations of interest to the BEG consists of (1) an early phase, object of this paper, in which CO2 is injected into the oil-bearing reservoir (the so-called Phase II) and (2) a second phase (started on December 1, 2009) in which CO2 is injected at a high rate (>100 kt/yr for several years) in the saline aquifer down dip of the reservoir (Phase III). We present the modeling efforts related to the early phase of injection (Phase II, started in July 2008) in which CO2 is injected into the oil-bearing reservoir. The objectives of the modeling effort are to (i) to gain insights on how to approach CO2 injection modeling at the site, (ii) to match recent pressure measurements at several wells including a dedicated observation well, and (iii) to vindicate the necessity of monitoring of reservoir pressure. Its intent is not necessarily to do a full-fledged history match of the historical production period (1940's – 1960's).

We conducted numerous repeat simulation runs to modify boundary conditions, fluid properties, and reservoir properties to match observed fluid responses to production and to injection. A good understanding of subsurface heterogeneities, and composition of the oil and gas components, and boundary conditions of the reservoir is the key to successful history matching. However, allocating the correct distribution of rock properties based on historical geophysical logs remained an area of uncertainty even as additional new data were obtained during characterization because of the complex interplay between depositional environment and strong overprint of diagenetic events. Parameters of utmost importance for a correct description of a flow field, in particular the relationship between porosity and permeability and the nature of permeability spatial variations remain uncertain as well as boundary conditions. The uncertainty was dealt with through sensitivity analyses. Ultimately, the constructed model shows a reasonable match with the data.

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