DFIT-FBA: A Made-in-Canada Well-Testing Method for Estimating Critical Unconventional Reservoir Properties

C.R. Clarkson, Department of Earth, Energy, and Environment, University of Calgary

Summary

Diagnostic fracture injection tests (DFITs)[1-11] are currently the most popular well-testing method applied to low-permeability (unconventional) reservoirs for obtaining minimum in-situ stress, reservoir pressure and permeability, and other properties used in hydraulic fracture design, and development optimization. In the modern context of unconventional reservoir development, DFITs are commonly performed at the toe of a horizontal well before the main stages of hydraulic fracturing along the lateral. The conventional DFIT procedure involves pumping a water-based fluid into the well to achieve breakdown, propagation of a small hydraulic fracture, shutting the pump off, and analysis of the pressure falloff data to obtain the properties of interest. A primary drawback of the conventional (pump-in/shut-in) DFIT is the time required to obtain reservoir information – depending on the permeability of the reservoir, days, weeks, or even months may be required to obtain reservoir information.

As an alternative, the pump-in/flowback (PIFB) DFIT[12-14] was introduced specifically to accelerate closure and obtain rapid estimates of minimum in-situ stress, a key parameter used in hydraulic fracture design. The PIFB DFIT procedure involves flowing back the well through a surface choke after the pump shutdown and analysis of the flowing pressures during the flowback period to estimate minimum in-situ stress. A primary drawback of the early PIFB DFIT design is that due to the relatively high rate of flowback (e.g., 1/6 to 1/4 of the injection rate), connectivity with the reservoir can be lost, removing the possibility of obtaining reservoir information.

In subsequent work, the PIFB DFIT was further modified to allow all of the same information (including reservoir pressure and permeability) as the conventional (pump-in/shut-in) DFIT to be obtained, but in a fraction of the time (2-4 hours, as opposed to days, weeks). This new design, introduced in 2019, is referred to as DFIT-FBA[15-25], where 'FBA' refers to flowback analysis. The primary innovations of this new design include flowing back at a lower rate (generally between 2-5% of injection rate but must be designed specifically to account for reservoir property variability) to maintain reservoir connectivity, and the analysis of flowback rates/flowing pressures using rate-transient analysis (RTA) techniques to estimate reservoir pressure and permeability. While conventional DFIT pressure falloff data may be analyzed using pressure-transient analysis (PTA) techniques, this is generally not the case with DFIT-FBA, as the rates will affect the RTA signature and the derived properties. A rigorous workflow for DFIT-FBA has been introduced[25] but continues to evolve.

While DFIT-FBA was first field-trialed in western Canada, subsequent tests have been performed in Australia, the U.S. (multiple basins), and South America, with well over 300 tests performed to date in a variety of reservoir types. The speed of DFIT-FBA has enabled applications of DFITs not previously (practically) possible, such as rapid screening of unconventional reservoir intervals during exploration programs[17], implementation of multiple tests along a lateral[20], evaluation of the risk of induced seismicity (through identification of fault zones)[23], and selection of the optimal fluid for hydraulic fracturing[24]. Relevant to the energy transition, the test has shown promise for evaluating enhanced geothermal systems (EGS)[26] and could be used for determining caprock properties critical to the containment of CO_2 (or gas storage generally).

However, DFIT-FBA is a relatively new method, and improvements to test, design, and analysis are ongoing[25]. For example, research is underway to increase the reliability of reservoir pressure estimates obtained from RTA of the flowback data and corrections for the effects of near-wellbore tortuosity.

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