Bluebonnet: Scaling solutions for production analysis from unconventional oil and gas wells

**Frank Male** [1,2,¶], **Michael P. Marder**[2], **Leopoldo M. Ruiz-Maraggi**[2], **and Larry W. Lake**[2]

1 Pennsylvania State University, University Park, PA, USA **2** University of Texas at Austin, TX, USA **¶** Corresponding author

Summary

Unconventional oil and gas wells are only productive due to extensive hydraulic fracturing treatments. Therefore, the character of their production over time is greatly influenced by engineering decisions. However, it can be difficult to separate the engineering decisions from the effects due to fluid properties. Also, during production these wells might be producing oil, gas, and water simultaneously, with each phase interacting with the others. Numerical tools are necessary to fully capture the effects of fluid properties on production.

`Bluebonnet` is a Python package that uses dimensionally scaled solutions of a pressure diffusivity equation to analyze, history-match, and forecast production of tight-oil and shale gas wells. Bluebonnet has been developed to help researchers and petroleum engineers analyzing production data from unconventional (shale gas and tight oil) wells. It provides the user with a set of tools to evaluate production performance of tight-oil and shale gas wells. These tools provide the following functionality:

1. `bluebonnet.fluids`: pressure-volume-temperature properties for oil, water, and gas phases.
2. `bluebonnet.flow`: physics-based production curves and hydrocarbon recovery factors.
3. `bluebonnet.forecast`: fits and forecasts for unconventional production.

The `fluids` submodule estimates the formation volume factors, solubility ratios, and viscosity for the oil, water and gas phases given the reservoir temperature, oil API gravity, gas specific gravity, and initial gas/oil ratio.

The `flow` submodule solves the pressure diffusivity equation to provide estimates of the hydrocarbon production over time and the hydrocarbon recovery factors. This module allows the user to estimate production for shale gas wells using scaled solutions of the single-phase real gas diffusivity equation (Male, 2015; Patzek et al., 2013). In addition, this module simulates production for tight-oil and gas condensate wells using a two-phase scaled solution of the pressure diffusivity equation (Ruiz Maraggi et al., 2022a). The `flow` submodule also allows users to capture production variations due to changes in bottomhole pressure.

The `forecast` submodule performs history matches and forecasts the production of unconventional wells using the scaling solutions present in the `flow` module. The `forecast` submodule also allows users to history-match and forecast production of wells subject to variable bottomhole pressure conditions using a modification of the approach developed by Ruiz Maraggi et al. (2022b).

Statement of need

`Bluebonnet` is a Python package using petroleum engineering methods to perform production analysis of hydrofractured wells. Parts of this code were first developed to assist in determining U.S. shale gas reserves (Male, 2019; Patzek et al., 2013).

There are no free open-source tools that use physics-based scaled flow solutions of the diffusivity equation to perform decline-curve and rate-transient analysis for unconventional reservoirs like `bluebonnet`. The goal for producing this software package is to provide researchers and reservoir engineers with a free and open source tool suitable to analyze production from unconventional (tight oil and shale gas) reservoirs.

The present library can be used for the following tasks:

1. Estimate fluid properties of reservoir fluids.
2. Build type curves and recovery factors for shale gas and tight-oil reservoirs.
3. History-match and forecast the production of shale gas and tight-oil wells.
4. Perform Rate-transient analysis (rate-time-pressure) of unconventional reservoirs.

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