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To cite this article: Weixia Liu et al 2019 IOP Conf. Ser.: Earth Environ. Sci. 242 022063

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Analysis and Evaluation of Well Testing in Conglomerate Reservoir

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Abstract. Due to the complexity of sedimentary conditions and the complicated lithology of formation, conglomerate reservoir has strong heterogeneity. It’s important to recognize the regularities of the well test response. Through 61 well testing interpretations in Xinjiang oilfield, the statistical analysis on the double logarithm curve types and characteristics of reservoir were carried out and the common regularities were analyzed. The results showed that near wellbore permeability of the injector is higher; permeability between the injector-producer was lower, which was a typical composite reservoir model. And the permeability changed over time, which greatly influenced by injection rate. The well test analysis and the evaluation results applied well in Xinjiang oil field during the process of profile control.

1. Introduction
Conglomerate reservoir is sediment dominated by strong heterogeneous piedmont pluvial facies. Due to the complexity of sedimentary conditions, the reservoir has strong heterogeneity. This heterogeneity is mainly reflected in large differences in mineral composition, different particle sizes, sharp changes in longitudinal and lateral facies, and heterogeneous height within the layer and interlamination.

2. Reservoir overview
The reservoir of Karamay Oilfield belongs to a classical of tectonic lithological conglomerate reservoir under the cover of medium-shallow fault. The reservoir has the following geological features.

(1) Strong heterogeneity is mainly reflected in large differences in mineral composition, different particle sizes, sharp changes in longitudinal and lateral facies, and heterogeneous height within the layer and interlamination.
(2) Pore structure has complex mode feature. Pore structures formed by gravel and sand are partially filled with clay particle. The feature of this complex mode structure determines that conglomerate reservoir has lower porosity and lower permeability, and the porosity and permeability parameters are affected by sedimentary facies. Therefore, the degree of heterogeneity is serious, which affects the water flooding efficiency.

Through well testing analysis and evaluation of the same district reservoir, the features of this district conglomerate reservoir have been further understood. It can guide well and layer selection and pressure design in the process of profile control agent injection. It has achieved some good application effects.

3. Analysis of well testing in conglomerate reservoir

3.1 Well performance testing
Through well testing performance of this district injection well, interpretation curve has the following features. Inflection point of interpretation curve is obvious, that is, when water injection speed increases within a certain range, curve of water injection pressure and water injection speed stay in a straight line. When water injection volume continues to increase, a more obvious inflection point appears, as shown in Fig. 1. Appearance of broken line is due to that new layers or small cracks begin to absorb water [5]. That is, low permeability area begins to absorb water, indicating that physical properties of conglomerate reservoir are not constant and are affected by water injection speed.

![Fig.1. Interpretation curve of well performance testing](image)

3.2 Transient well test interpretation of conglomerate reservoir
Pressure difference data of pressure drop or pressure recovery and time are plotted in double logarithmic coordinate system. Various parts of the curve can characterize different flow stages. Some characteristic parameters can be obtained from different flow stages [4].

Through double logarithmic curve of pressure recovery testing data, double logarithmic curve of this district conglomerate reservoir reflects composite reservoir characteristic obviously. Figure 2-5 shows double logarithmic curve of well testing for well T7241 at different times.

It can be seen from the following figures that after a short-term radial flow in inner zone occurs, then reservoir physical property of outer zone deteriorates, and double logarithmic curve is upward.
Fig. 2. Double logarithmic chart of well testing pressure for well 7228 (2010-10-31)

Fig. 3. Double logarithmic chart of well testing pressure for well 7228 (2010-12-22)

Fig. 4. Double logarithmic chart of well testing pressure for well 7228 (2011-4-2)

Fig. 5. Double logarithmic chart of well testing pressure for well 7228 (2011-11-30)
Table 1 Interpretation results of well testing for well 7228

| date           | Well storage coefficient, m³/MPa | Skin factor | Inner radius/m | Inner permeability/mD | Outer permeability/mD |
|----------------|----------------------------------|-------------|----------------|-----------------------|-----------------------|
| 2010/10/31     | 0.16                             | -1          | 18             | 25                    | 6                     |
| 2010/12/22     | 2                                | -1          | 28             | 58                    | 1.5                   |
| 2011/4/2       | 0.48                             | -1          | 25             | 40                    | 2.5                   |
| 2011/11/30     | 0.2                              | -1          | 15             | 15                    | 3.5                   |

Table 1 shows result of well testing interpretation for well 7228. It can be seen from the table that permeability of near wellbore is relatively high, but permeability of outer zone is low; and permeability changes over time.

Inner and outer zone permeability obtained from well testing interpretation of other wells in the district is counted as shown in Fig. 5.

It can be seen from Fig. 6 that permeability of outer zone of water well is lower than that of the inner zone, which indicates that near wellbore zone of water well is affected by reservoir reformation, pressure induced crack, water injection, etc. Effective permeability of near wellbore zone is higher than that of the outer zone. Permeability of outer zone can represent reservoir seepage ability before production. This reflects heterogeneity of conglomerate reservoir plane. In the later measures such as profile control, influence of permeability of inner and outer zone should be taken into account.

Fig. 6. Permeability statistics for inner and outer zone of injection wells in the region of interest

4. Application of well test results in conglomerate reservoir

In the process of well and layer selection in conglomerate profile control, near-wellbore permeability, inter-well permeability and radius of inner zone obtained by well testing interpretation can be used to build inter well permeability distribution model and provide quantitative basis for selection and dosage design of profile control system, as shown in Figure 7.
Near-wellbore permeability of water well characterizes injectability of profile control system, which is main basis for selecting the system. According to pressure drop curve of injection well, permeability of inner zone affects the speed of pressure drop. Permeability of inner zone is higher, and pressure drop is faster, which indicating that profile control agent is highly injectable. Inner zone radius of water well is one of the main basic factors for dosage design. Wellbore storage coefficient is one of the most important parameters for correcting dosage of profile control agent. Inner zone controls injected amounts of the agent, and outer zone controls the inter-well pressure difference. Pressure design of profile control should take characteristics of well performance testing curve into account. That is, injection pressure is not necessarily linear with injection volume when profile control agent is injected at a higher velocity. After the curve reaches inflection point, injection pressure increases less and injectability increases.

5. Conclusions
(1) Well testing interpretation of conglomerate reservoir shows that after injection velocity increases to a certain value, curve slope of injection pressure and injection volume becomes smaller, and injection pressure increases less, indicating that fluid injectability is better at high injection velocity.

(2) Double logarithmic curve of pressure recovery well test of conglomerate reservoir has obvious composite reservoir characteristic. Permeability of inner zone is better than that of outer zone, and permeability of inner and outer zone changes with time.

(3) In the design of conglomerate reservoir profile control scheme, results of well test interpretation should be taken into account. For example, layer and well selection of profile control should take injectability of the agent affected by near wellbore permeability into account. Profile control should take radius of inner zone and wellbore storage coefficient into account. Injection pressure of profile control should consider that fluid injectability increases at high injection velocity.

Acknowledgments
This work was financially supported by National Science and Technology Major Projects (2017ZX05009004, 2016ZX05058003).

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