Supplementary file

Feasibility analysis of storing solar energy in heterogeneous deep aquifer by hot water circulation: insights from coupled hydro-thermo modeling

Yanyong Wang [1,2,3], Kunpeng Zhong [1], Yihua Gao [5], Zhenjie Sun [1], Rencheng Dong [4], Xiaoguang Wang [1,2,3*]

[1] College of Energy, Chengdu University of Technology, Chengdu 610059, P. R. China

[2] National Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, P. R. China

[3] Tianfu Yongxing Laboratory, Chengdu 610213, P. R. China

[4] Oden Institute for Computational Engineering and Sciences, The University of Texas at Austin, Austin, TX, 78712, USA

[5] CNOOC Research Institute Co., Ltd., Beijing 100028, P. R. China

E-mail address: wangyanyong@cdut.edu.cn (Y. Wang); kunpengzhong11@gmail.com (K. Zhong); gyhupc@163.com (Y. Gao); sunzhenjie92@163.com (Z. Sun); rencheng_dong@utexas.edu (R. Dong); wangxiaoguang@cdut.edu.cn (X. Wang).

*Corresponding author (ORCID: 0000-0003-3624-1773)

Wang, Y., Zhong, K., Gao, Z., et al. Feasibility analysis of storing solar energy in heterogeneous deep aquifer by hot water circulation: insights from coupled hydro-thermo modeling. Advances in Geo-Energy Research, 2023, 10(3): 159-173.

The link to this file is: https://doi.org/10.46690/ager.2023.12.03

1. Simulation results

1.1 Influence of buoyancy-driven flow

The variation of bottomhole pressure of the injection well over whole operation period is shown in **Fig. S1**. The bottomhole pressure declines gradually with the proceeding of heat storage in the subsurface, and meanwhile a certain degree of fluctuation can be observed, which can be attributed to the repeated well opening and closing operations. The difference in bottomhole pressure is not obvious for cases with and without consideration of gravity. However, the operation pressure for hot water injection into heterogeneous aquifer is obviously higher than that of homogeneous aquifer.

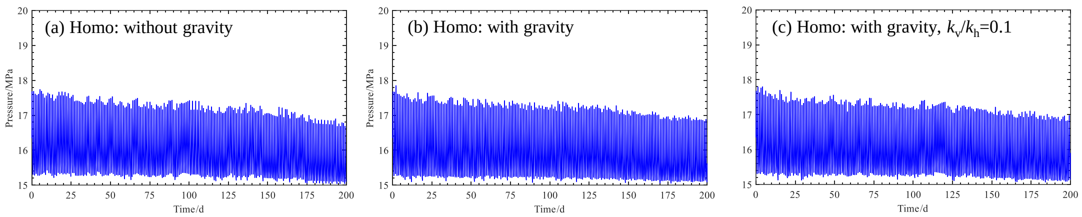

Fig. S1. Bottomhole pressure of injection well during whole hot water circulation process for case without gravity (a), with gravity (b) and under anisotropic condition (c).

1.2 Influence of injection conditions

The variation of bottomhole pressure for injection well over whole circulation process under different injection rates is given in **Fig. S2**. It is clear that the increase of injection rate elevates the operation pressure (**Fig. S2**).

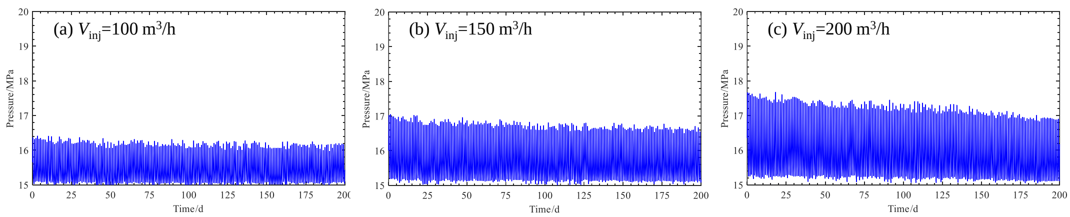

Fig. S2. Evolution of bottom hole pressure for injection well over whole circulation process under different injection rates.

The bottomhole pressure for injection well over whole circulation process under different injection temperature is given in **Fig. S3**. The increase of injection temperature from 150°C to

250°C causes negligible effect on injection pressure (**Fig. S3**).

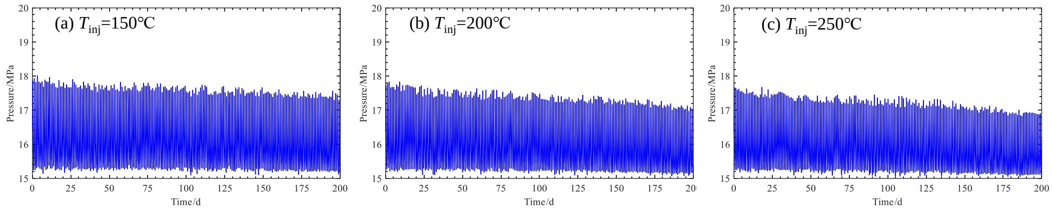

Fig. S3. Evolution of bottom hole pressure for injection well over whole circulation process under different injection temperature.

1.3 Influence of average permeability

The evolution of produced water temperature and bottomhole pressure of injection well over whole circulation process are given in **Fig. S4 and S5**. It can be seen that the increase of permeability enlarge the fluctuation of produced water temperature, and a high injection pressure can be encountered for aquifer with permeability of 50 mD.

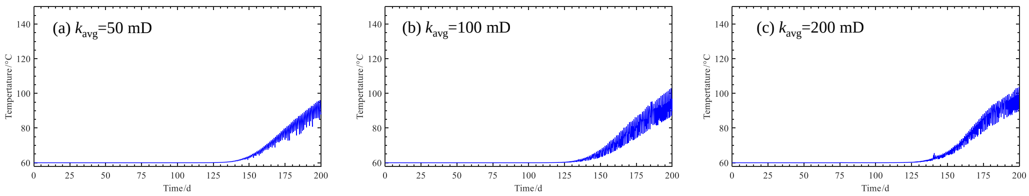

Fig. S4. Evolution of produced water temperature over whole circulation process for aquifers with different average permeability.

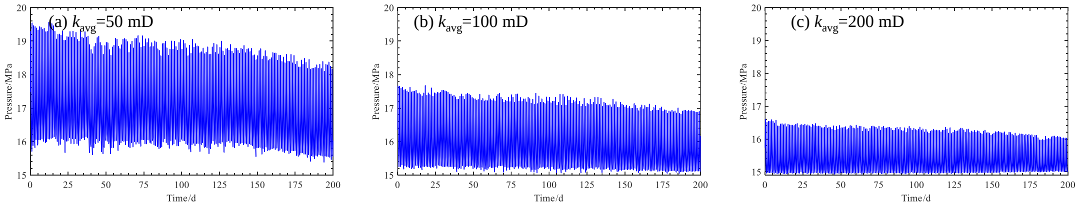

Fig. S5. Evolution of produced water temperature and bottom hole pressure for injection well over whole circulation process for aquifers with different average permeability.

1.4 Influence of permeability heterogeneity

1.4.1 Horizontal autocorrelation length

The bottomhole pressure of injection well over whole circulation process is given in **Fig. S6**. No noticeable variation of injection pressure is observed with the increase of horizontal correlation length. From the point view of heat storage quantity and efficiency, porous aquifers featured with smaller autocorrelation length will be more favored and suggested to be selected prior to field operation.

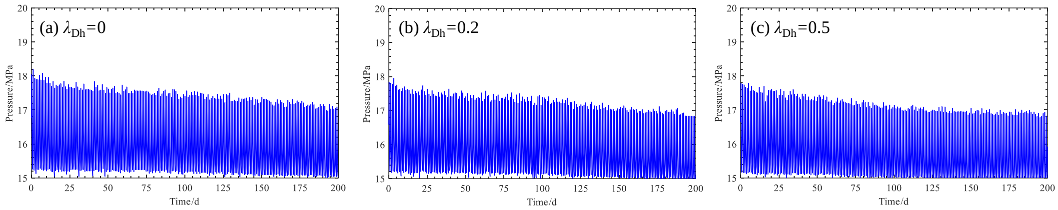

Fig. S6. Evolution of bottomhole pressure for injection well over whole circulation process. The average permeability for all cases equals 100 mD, vertical autocorrelation length equals 0, and V_{DP} equals 0.63.

1.4.2 Global permeability heterogeneity

The evolution of injection pressure over the whole circulation process is shown in **Fig. S7**. One can see that the enhancement of global permeability heterogeneity obviously elevates the injection pressure for hot water injection, which means additional operation costs will be required in field application.

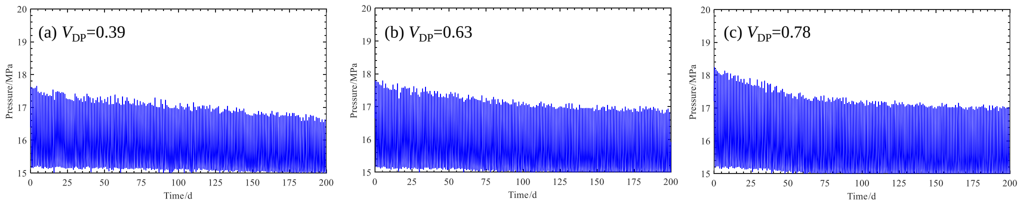

Fig. S7. Evolution of bottomhole pressure for injection well over whole circulation process. The horizontal autocorrelation length for all cases equal 0.5, and average permeability equals 100 mD.