利用井-儲水層結合流體和熱傳輸模型評估深層碳酸鹽地熱儲存層之能源生產率

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摘要

地熱為一潔淨且不受氣候或季節變化影響之能源；在中國，由於對潔淨能源之需求，要求需於深度大於 1000 公尺之地熱儲集層方能進行開發。在開採地熱能源前，利用數值模式推估深儲集層之地熱產能為必要之工作，其為提供不同選擇情境分析之有效工具，本研究針對中國天津市一液態水為主的中溫地熱儲集層能源產能進行數值分析，探討熱能與流體於異質性儲集層及深井之傳輸機制。經數值分析結果得到井距 850 公尺之典型地熱雙井系統最佳注入/生產率為 450 m^3/h，出流溫度和熱量提取速率分別可以達到 112°C 和 43.5 MW；經由降低注入／生產速率低於至 450 m^3/h，並改善注入井和生產井之配置（避免井間的高滲透區），可以降低熱突破的風險。如果儲存層中的低滲透率分佈在注水井周圍，往往導致井口壓力過高，此問題或可通過強化增產技術解決並實現穩定之操作模式，本研究之執行方法可提供條件類似的雙井開發作為參考。

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Research Article

Assessment of Energy Production in the Deep Carbonate Geothermal Reservoir by Wellbore-Reservoir Integrated Fluid and Heat Transport Modeling

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Geothermal energy is clean and independent to the weather and seasonal changes. In China, the huge demanding of clean energy requires the geothermal energy exploitation in the reservoir with depth larger than 1000 m. Before the exploitation, it is necessary to estimate the potential geothermal energy production from deep reservoirs by numerical modeling, which provides an efficient tool for testing alternative scenarios of exploitation. We here numerically assess the energy production in a liquid-dominated middle-temperature geothermal reservoir in the city of Tianjin, China, where the heat and fluid transport in the heterogeneous reservoir and deep wellbores are calculated. It is concluded that the optimal injection/production rate of the typical geothermal doublet well system is 450 m^3/h, with the distance between geothermal doublet wells of 850 m. The outflow temperature and heat extraction rate can reach 112°C and 43.5 MW, respectively. Through decreasing injection/production rate lower than 450 m^3/h and optimizing layout of the injection well and production well (avoiding the high permeability zone at the interwell sector), the risk of heat breakthrough can be reduced. If the low permeability zone in the reservoir is around injection well, it usually leads to abnormal high wellhead pressure, which may be solved by stimulation technique to realize stable operation. The methodology employed in this paper can be a reference for a double-well exploitation project with similar conditions.