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Understanding the Impact of Paleoclimate Corrections on the Cheshire Basin with Application to Deep Borehole Heat Exchangers

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The UK government has committed to achieving net zero carbon emissions by 2050; this can only be achieved if the supply of heat is decarbonised. Geothermal energy could play an important role in decarbonisation, due to the significant estimated geothermal potential in the UK. Furthermore, there are opportunities to repurpose existing infrastructure for geothermal development; there are c.2000 onshore ex-hydrocarbon wells in the UK (e.g., Watson *et al*., 2020), with many of these having the potential to be repurposed as closed-loop, deep borehole heat exchangers (DBHEs) with low geological risk, as there are no hydraulic interactions with a reservoir at depth (Nibbs *et al*., 2023).

In this study, the Cheshire Basin was investigated as it has a significant geothermal potential holding over 23 % of the energy from the UK's Mesozoic Basins (Downing and Gray, 1986; Rollin *et al*., 1995; Brown, 2023), and additionally, many wells have been drilled which could be re-entered and converted to DBHEs at relatively low-cost. Although there are significant resources associated to the basin, the heat flow is relatively poor and below the UK average. It is likely that estimates of heat flow have been underestimated as a consequence of not factoring in corrections of past paleoclimatic conditions. As a result, the Knutsford-1 borehole, within the Cheshire Basin, was selected as a case study to understand: i) the impact of Paleoclimate corrections on both heat flow in the Cheshire Basin, and on transient DBHE modelling simulations, ii) how engineering parameters can be optimised to maximise performance when repurposing an ex-exploration hydrocarbon well as a DBHE, and iii) to understand the impact of groundwater flow of varying deep geothermal reservoirs of thickness up to 2 km within the basin.

The uncorrected heat flow of the Knutsford-1 borehole was calculated through detailed analysis of the borehole's lithological and temperature logs. The effect of palaeoclimate on heat flow was then accounted for, following the methodology outlined in Westaway and Younger (2013). Corrected values indicate that past heat flow measurements within the basin have been underestimated and in shallow boreholes the impact could be even more pronounced. This not only impacts the prior basin-wide geothermal potential /basin basal temperature calculations, but also static and transient wellbore modelling.

Following the corrections of heat flow data, a series of numerical models were developed on OpenGeoSys to understand the static and transient thermal response of the subsurface for un-corrected and corrected heat flows. Optimum engineering conditions, such as flow rate and wellbore properties, were then established based on DBHE performance (i.e., from both hydraulic and thermal changes). Lastly, the impact of the mechanism of heat transfer in the subsurface around the DBHE was evaluated; the two scenarios considered were conductive and advective heat transfer around the DBHE (i.e., with or without groundwater flow).

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