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Deep Karst and the Geothermal Revolution: A UK Study on Resource Availability in Carboniferous Limestone

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Carboniferous limestone karst is a strong contender for geothermal exploration and exploitation in the UK, with karst systems known to facilitate the pathways of thermal spring waters. The King's Spring at Bath Spa (South-west England) for example emanates at the surface with temperatures of ∼44˚C and flow rates of approximately 600m^3/d[1]. Several tepid spring waters in the Peak District (Central England) have recorded values surpassing this flow rate, ranging between ∼800-2231 m^3/d. The potential transmissivity of karst systems is further highlighted by the predominant formation of interconnected cave networks in the limestone, such as the Three Counties Systems in the North Dales (Northern England). This evidence indicates potential for sufficient porosity and permeability at depth and therefore, there is plenty of scope to identify and quantify the size of this untapped resource.

A multidisciplinary approach is applied, utilising available well information, drill-core analysis, 2D seismic data and geochemistry data. Further flow rate and temperature data obtained from wells corroborates and supplements that which is measured at the surface – the Ridgeway borehole in Sheffield, for example, has recorded flow rates of 454.6m^3/d (converted from the imperial unit of 100,000 gallons per day) at a 883m depth, with a measured temperature of 48.9˚C[2]. The characterisation of drill-core has allowed for identification of palaeokarst – for example, at depths exceeding 1247.15m in Nettleham B2 (Lincolnshire, East Midlands). Seismic interpretation of unconformities are indicative of potential karst development with known low-angle unconformities at several well locations in the East Midlands having been identified, in addition to potentially high angle unconformities presently recognised in wells such as Hanbury-1, located near Burton-Upon-Trent (Central England). Here, the succession is a combination of limestone and sandstone with a Namurian supercrop. Geothermometry analyses of spring water and well water data have also been conducted indicating, for example, Na-K-Ca reservoir temperatures of 63˚C at King's Spring (consistent with the literature). However, further investigations suggest several of the spring waters have failed to achieve either partial or full equilibrium and therefore investigations on mixing processes must be pursued.

The research aims to confront the imminent challenge of energy security, as reflected by an increasing dependence on gas imports. UK gas import dependency is currently ∼50%, with a projected rise to almost 75% by 2030[3]. Almost 50% of the energy consumption in the UK is attributed to heat use[4]. Gas provides much of this heat, with dominant contributions of 71% and 79% to the service and domestic sectors, respectively[4]. Therefore, it is comprehensible that geothermal energy could pose a possible alternative to the gas dependency that is forecasted.

References

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