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High Rayleigh number porous convection DUNCAN HEWITT, JOHN LISTER, JEROME NEUFELD, DAMTP, University of Cambridge — Convective flow in porous media undergoes a transition around Rayleigh number $Ra = 1300$, from predominantly large-scale (quasi-) periodic rolls to vigorous columnar exchange flow driven by unsteady plume formation in boundary layers. The dynamics of these structures determine the flux of heat or solute through the system, as described by the Nusselt number Nu. This is of particular interest for understanding how convection affects the rate of dissolution of sequestered CO_2 in a saline aquifer. High resolution 2D numerical simulations of porous media Rayleigh-Benard convection are presented, which show that, for $2000 < Ra \leq 40000$, the dependence of Nu on Ra is slightly weaker than the classical scaling $Nu \propto Ra$. However, the numerical results strongly suggest that the classical scaling is attained asymptotically, contrary to previous indications. The relationship between $Nu(Ra)$ and the global structure of the flow is discussed. This structure is characterised in the interior by vertical columnar exchange flow across the height of the box at a (statistically) regular wavelength, and near the boundaries by short wavelength boundary layer instabilities driving proto-plume growth and entrainment into the interior mega-plume flow. The dynamics of the system at all scales are analysed, with the aim of understanding the dominant physical processes.

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