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Mixed Convection in Saturated Porous Media

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I. INTRODUCTION

Early studies on convection in porous media were largely devoted to buoyancy-induced flows and forced convection. The interaction mechanism between these two modes of convection was given very little attention. Initial research on mixed convection was motivated by the desire to provide a basic understanding of the upward convective drift of subsurface ground water due to buoyancy caused by high temperatures in the geothermal region of Wairakei, New Zealand (Wooding 1960, 1963). Research on mixed convection in porous media was also performed to study the formation of an island geothermal reservoir after a magma chamber was intruded from below (Cheng and Teckchandani 1977; Cheng and Lau 1977; Cheng 1978).

In addition, the design of a saltless solar pond requires a basic understanding of continuous withdrawal of warm water from the bottom of the pond for distribution to the point of use while cool make-up water is continuously added at the top. This creates a gentle flow downward in the direction of increasing temperature, i.e., an opposing forced flow in a volumetrically heated packed bed (Hadim and Burmeister 1988). In another solar space heating application, a horizontal packed bed is charged by passing hot air from solar collectors through the bed horizontally (Salt and Mahoney 1987).

Motivation to study mixed convection in porous media has also come from the need to characterize the convective transport processes around a

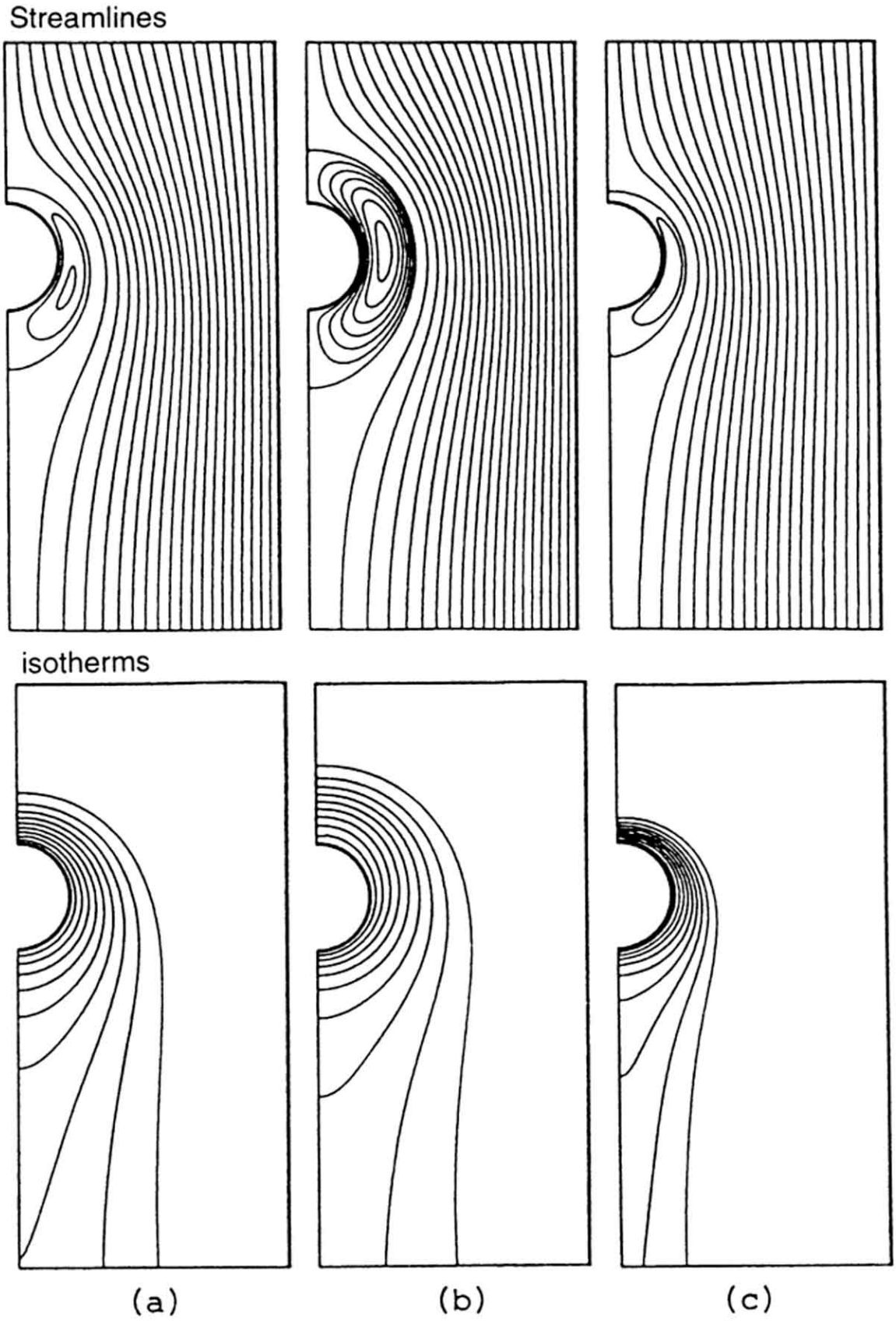

Figure 12. Flow and temperature fields for opposing mixed convective flow past a horizontal cylinder in a saturated porous medium: (a) $Re = 20$, $Gr = 60$; (b) $Re = 20$, $Gr = 80$; (c) $Re = 100$, $Gr = 300$ (Zhou and Lai 1998).