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Models of geothermal surface features at Wairakei

by

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Abstract

Analytical and numerical models of heat and mass transfer in geothermal soils are calibrated using soil temperature time series, porosity, and saturation data from four sites at the Karapiti Thermal Area, Wairakei. The Karapiti data were collected by Bromley and Hochstein (2001). They measured temperature at several sites over periods of four to seven days at the soil surface and at depths of 0.01, 0.05, 0.1, 0.15, 0.2 m.

Thermal conductivity estimates for Karapiti soils as a function of saturation show that the dry and wet thermal conductivities for these soils is 0.1 W/mK, and 0.8 W/mK respectively.

Fourier analysis of the soil temperature data shows that the diurnal term is dominant in all cases. The Fourier analysis gives, at each depth, the mean temperature and the amplitude and phase shift of the diurnal component of the temperature.

The analytical models are used to derive estimates of thermal diffusivity which range from 2.8 x 10^{-7} to 6.1 x 10^{-7} m^2/s for the pumice soils sampled. The mean temperature versus depth profiles are non-linear and indicate that mass flow and associated advective heat transfer is important in warm ground.

Numerical modelling results show that mass flows and total heat flows are between 0.00065 and 0.00175 kg/s/m^2 and 148 and 917 W/m^2, respectively, for the Karapiti sites. The heat flows are comparable to calorimeter measurements from Karapiti (Hochstein et al. (2005)).

The second part of this study uses flow data from three geothermal features at the Alum Lakes, Wairakei, and Wairakei reservoir data, to calibrate a two-dimensional model of the Wairakei geothermal system. The model is based on an existing three-dimensional computer model of Wairakei system, but uses a finer grid in the vicinity of the Alum Lakes. The results show that pressure decline in the Wairakei reservoir has resulted in a cessation of the geothermal up-flow to the overlying Alum Lakes, and the Alum Lakes feeder conduit now hosts a down-flow of groundwater.
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