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Reinjection and gravity changes at Rotokawa geothermal field, New Zealand

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Abstract

Since commissioning in late 1997, heat-depleted wastewaters from Rotokawa power station have been reinjected into a shallow two-phase aquifer, which is separated by a low-permeability zone from the deeper exploited reservoir. Gravity changes for 1997–2003 show a large positive (341 μgal), near-circular anomaly, centred near the reinjection wells. Modelling shows that the anomaly is associated mainly with the introduction of the cooler reinjected waters into the reinjection aquifer, resaturating the pores by displacing steam. The region of liquid resaturation had the shape of a cone of impression, which reached from the bottom of the reinjection aquifer up to shallow (100–200 m) depths. The gravity changes represent a net mass gain of 8.6 million tonnes and the near-circular shape indicates that the horizontal permeability of the resaturated region was isotropic. Gravity changes for 2003–2004 occurred at most of the points that previously had large gravity increases, however, the region of the gravity increases is not radially symmetrical, suggesting that resaturation had become anisotropic in the horizontal plane. Modelling also suggests that the cone of impression had not increased in height during 2003–2004 but had expanded laterally by up to 30 m, except in a southerly direction, where it may have extended up to 2 km.

The repeat gravity measurements were the key to understanding the directions taken by the injectate as it flowed through the system, and explained the increased pressure in the reinjection aquifer. Shallow reinjection is unsustainable in the long-term because the two-phase zone would eventually become liquid-saturated. Deep reinjection was therefore initiated in two wells on the western margin of the reservoir in 2005.

Keywords: Reinjection; Gravity changes; Liquid resaturation; Fluid chemistry; New Zealand

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1. Introduction

Rotokawa is a high-temperature, liquid-dominated geothermal field situated in the Taupo Volcanic Zone (Fig. 1), about 5 km east of the Wairakei geothermal field and 12 km northeast of the town of Taupo. Electrical resistivity measurements indicate that the Rotokawa field has an area of about 25 km^2 and straddles the Waikato River (Fig. 2). The field is manifested at the surface, mainly on the south-eastern side of the river, by steam-heated (acid sulfate) features: a shallow acid lake (Lake Rotokawa), several small hot springs and seeps in the bed and banks of the river, and a few fumaroles. Water flows out from the eastern end of the lake into the Parariki Stream,

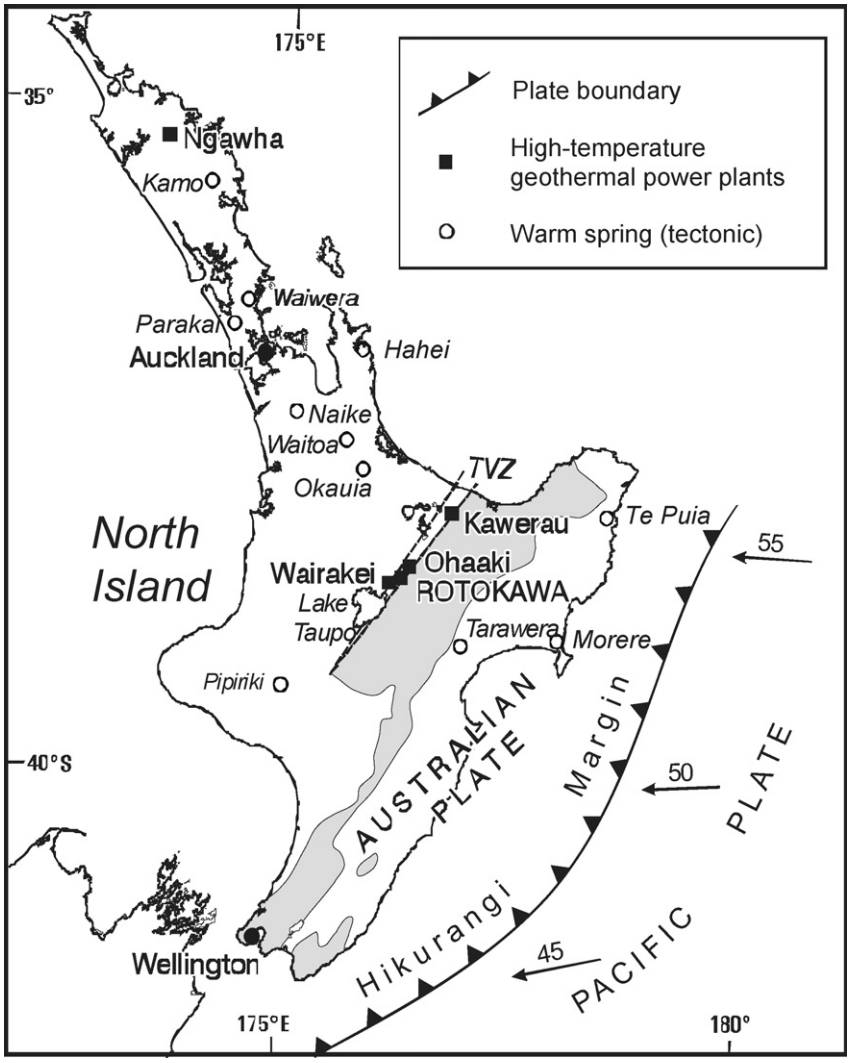

Fig. 1. Tectonic map of the North Island of New Zealand, showing the location of the Taupo Volcanic Zone (TVZ) and of high-temperature geothermal systems, including the Rotokawa field. Arrows show the relative directions and rates of tectonic plate convergence (in mm/year).