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DEVELOPMENT OF A LOW-ENTHALPY WATER RESOURCE AT WHITFORD, EAST AUCKLAND

Barbara Simpson and Kevin Tearney

GCNZ Consultants, Auckland

ABSTRACT

Understanding the hydrology of the warm groundwater resource at Brownhill Road, Whitford has in the past been limited by lack of data. A recent resurgence of interest in the resource has resulted in the collection of a large amount of new geological, geochemical and geophysical information. In particular, a new gravity profile was installed to gain better knowledge of the basement structures which control the upflow of warm water. Interpretation of this profile has identified a new structure, the Polo Lane Fault, which intersects the Whitford Fault near the southern end of Brownhill Road.

1 INTRODUCTION

The existence of warm groundwater along Brownhill Road at Whitford has been recognised for more than twenty years (Waterhouse, 1965). A number of farm bores in the area produce warm boron-rich water, but this has always been somewhat of an annoyance for the farmers who need good quality water for stock and domestic use. It has only been in very recent years that the intrinsic value of this warm water as a source of heat has been appreciated.

A proposal to develop the warm water resource for recreational purposes foundered in 1986 when the Planning Tribunal cancelled a Water Right to take 1000 m^3/day of warm groundwater. The Tribunal found "that abstraction at the rate permitted by the water right would seriously deplete the resource by gradually reducing both the temperature and the amount of available fluid" (NZTPA, 1986). However, the time scale over which such a change might occur could not be adequately predicted because of insufficient knowledge about the nature and extent of the warm water resource.

Subsequently Motor Holdings Limited has purchased the two properties on Brownhill Road which were the subject of the Planning Tribunal decision. The company has set about gathering data to improve the state of knowledge of the warm water resource with a view to developing it in the most beneficial way for the enjoyment of the general public. GCNZ Consultants were engaged by Motor Holdings to undertake a large part of this work.

This paper presents a reassessment of the basement structure underlying Motor Holdings Ltd property incorporating recent gravity measurements. This structural interpretation forms the basis for a new conceptual model of the warm water hydrological system (GCNZ, 1987).

GEOLOGICAL SETTING

Throughout the Auckland region, basement consists of Waiheke Group rocks (greywacke) which are intensely indurated and closely jointed. These are overlain by Waitemata Group rocks which outcrop over much of Auckland, and consist of thick bedded sandstone and minor thin mudstone with basal conglomerates and localised thin basal limestone (Schofield, 1967). At Brownhill Road, Whitford, Waitemata Group rocks are typically less than 100 m thick and greywacke outcrops about 2 km south east of Motor Holdings Limited property. Within this study area, the Waitemata Group rocks are fine-grained and have extremely low horizontal permeability ($k = 10^{-6}$ to 10^{-8} m/s). In contrast the underlying greywacke can have very high permeability where the rock is heavily fractured (typically $k = 10^{-3}$ m/s).

The density contrast between greywacke (ρ = 2.67 Mg/m^3) and the Waitemata rocks (ρ = 2.28 Mg/m^3) indicates gravity surveying as a useful technique for defining basement topography. By good fortune, the East Auckland area has already been the subject of extensive gravity surveying (Woodward, 1971; Anderson, 1977; Nixon, 1977). Schofield (1982) has used these gravity results and his own geological field observations to develop a structural map of East Auckland which is a considerable refinement of earlier ideas (Schofield, 1967). In particular, the Drury Fault is no longer shown as a continuous N to NNW trending structure. It is broken by several NE trending faults in the vicinity of Alfriston/Brookby and its "northern extension" is now called the Whitford Fault. This structure was located in the Brownhill Road area on the basis of existing warm water bores.

Earlier tests of the hydrological system at Brownhill Road (GCNZ, 1984) show that the greywacke aquifer has a large yield capacity which is not restricted by close boundaries. Both the water temperature and boron concentration suggest a flow pattern which is generally northwards away from a buried source. Furthermore, the depth to greywacke indicates that the warm water bores are probably located on the upthrown (eastern) side of the Whitford Fault. These observations are inconsistent with the concept that vertical permeability associated with the Whitford Fault defines the primary upflow zone.

NEW GRAVITY DATA

To further investigate the greywacke basement topography in the vicinity of Brownhill Road, GCNZ Consultants installed a new gravity profile in May 1987 (Fig 1). The profile involved 17 gravity stations over about 8 km and measurements were made using Worden meter No 240. It was

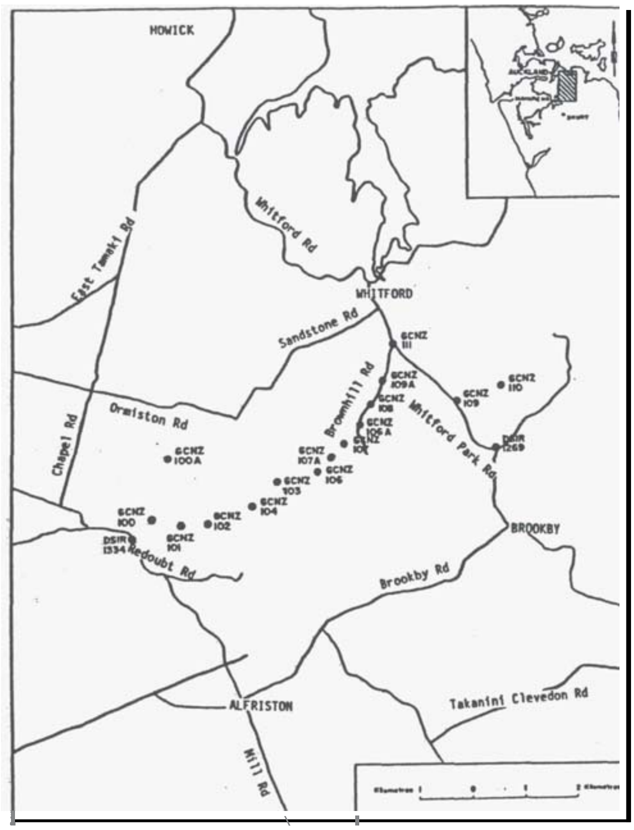

Figure 1 - Location map showing the 17 gravity stations on the GCNZ profile

originally intended to run the profile approximately perpendicular to the trend of the Whitford Fault as inferred by Schofield (1982), but difficulties with access to land between Brownhill Road and Whitford Park Road eventually led to measurements being made along Brownhill Road. The gravity observations were tied in to the DSIR regional gravity network at DSIR gravity stations 1269 and 1334 (Woodward, 1971) to produce Absolute Bouguer Anomalies. Terrain corrections were estimated in the field for Hammer Zones B to D and calculated using standard graticles to Hammer Zone M from 1:25,000 and 1:50,000 topographic maps. The regional Bouguer gravity field defined by Anderson (1977) for a profile (Profile B) approximately 2 km north of the GCNZ profile, was adopted and used to deri've residual Bouguer Anomalies.' Table 1 lists the data and corrections applied and the results are plotted in Figure 2. This figure also incorporates ground surface elevation and an interpretation of the basement topography which is inferred from known depths to greywacke and by coinparison with Anderson's (1977) interpretation of similar anomalies from Profile B.

TMLE 1
RESULTS OF GCNZ GRAVITY PROFILE

STATION	ELEVATION (m asl)	OBSERVED GRAVITY (mgal)	TERRAIN CORRECTION (mgal)	BOUGUER ANOMALY (mgal)
DSIR 1334	115.7'	47.30		47.5
GCNZ 100	66.1'	59.69	0.09	50.1
GCNZ 100A	56.0'	62.58	0.05	51.9
GCNZ 101	65.9'	58.44	0.08	48.8
GCNZ 102	79.9+	57.35	0.13	50.5
GCNZ 104	117.6'	48.93	0.41	50.5
GCNZ 103	129.0'	47.66	1.03	51.9
GCNZ 106	83.94"	58.36	0.55	52.94
GCNZ 107A	46.80*	66.81	0.16	52.82
GCNZ 107	18.13"	73.07	0.35	53.46
GCNZ 106A	14.93"	73.55	0.41	54.85
GCNZ 108	12.71*	73.98	0.51	53.39
GCNZ 109A	10.82*	73.90	0.30	55.08
GCNZ 111	13.32*	71.88	0.09	53.91
GCNZ 109	49.6'	66.69	0.13	55.1
GCNZ 110	84.5'	72.74	0.55	56.0
DSIR 1269	20.6'	60.14		54.5

\+ determined by barometry - Bouguer anomaly ± 0.5 mgal
• determined by precise levelling - Bouguer anomaly ± 0.1 mgal

It is clear from Figure 2 that depth to basement in general increases to the west along the profile. The most rapid changes occur between stations GCNZ 110 and GCNZ 111, GCNZ 108 and GCNZ 107 and then west from GCNZ 107A.

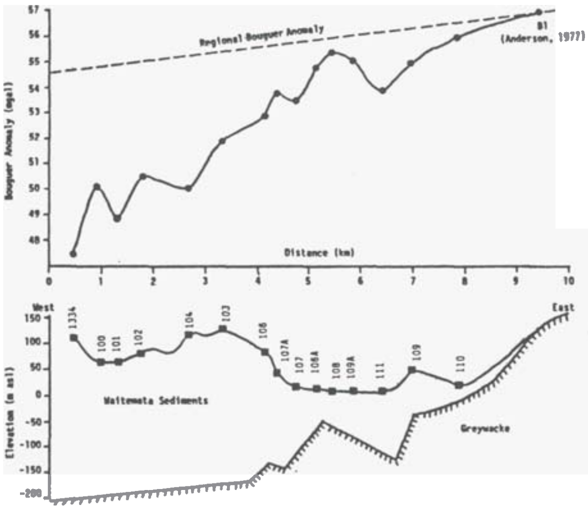

Figure 2 - Absolute Bouguer Anomalies, ground surface elevation and inferred basement topography for the GCNZ profile

INTERPRETATION OF BASEMENT TOPOGRAPHY

The density of gravity data in the East Auckland area is now quite high so the Bouguer Anomalies may be contoured with some degree of confidence. The resulting contours support the general form of Schofield's (1982) structural interpretation, but the GCNZ gravity profile has identified additional basement displacements which are not accounted for by Schofield. An alternative interpretation which incorporates all the known basement displacements, known relative levels of the greywacke surface and is consistent with the Bouguer Anomaly contours is given in Figure 3. The most significant new inferrence is the extension of the Polo Lane Fault south westwards across the end of Brownhill Road based on the displacements inferred from gravity anomalies between GCNZ 110 and GCNZ 111 and westwards from GCNZ 107A. In retrospect, it is perhaps fortunate that the GCNZ profile did not follow a NE trending line because this may well have been coincident with the fault lineation and would not have given as much information. As it is, the western end of the profile runs parallel to the Polo Lane Fault so modelling in terms of 2-D density bodies was not undertaken.

The inferred intersection of Whitford Fault and Polo Lane Fault occurs beneath the property owned by Motor Holdings Limited. The hottest wells and the highest aquifer pressures are nearest the fault intersection. Aquifer temperatures drop off gradually to the north and more rapidly in other directions. A conceptual model which is consistent with all the known geological, geophysical and hydrological data is as follows :-

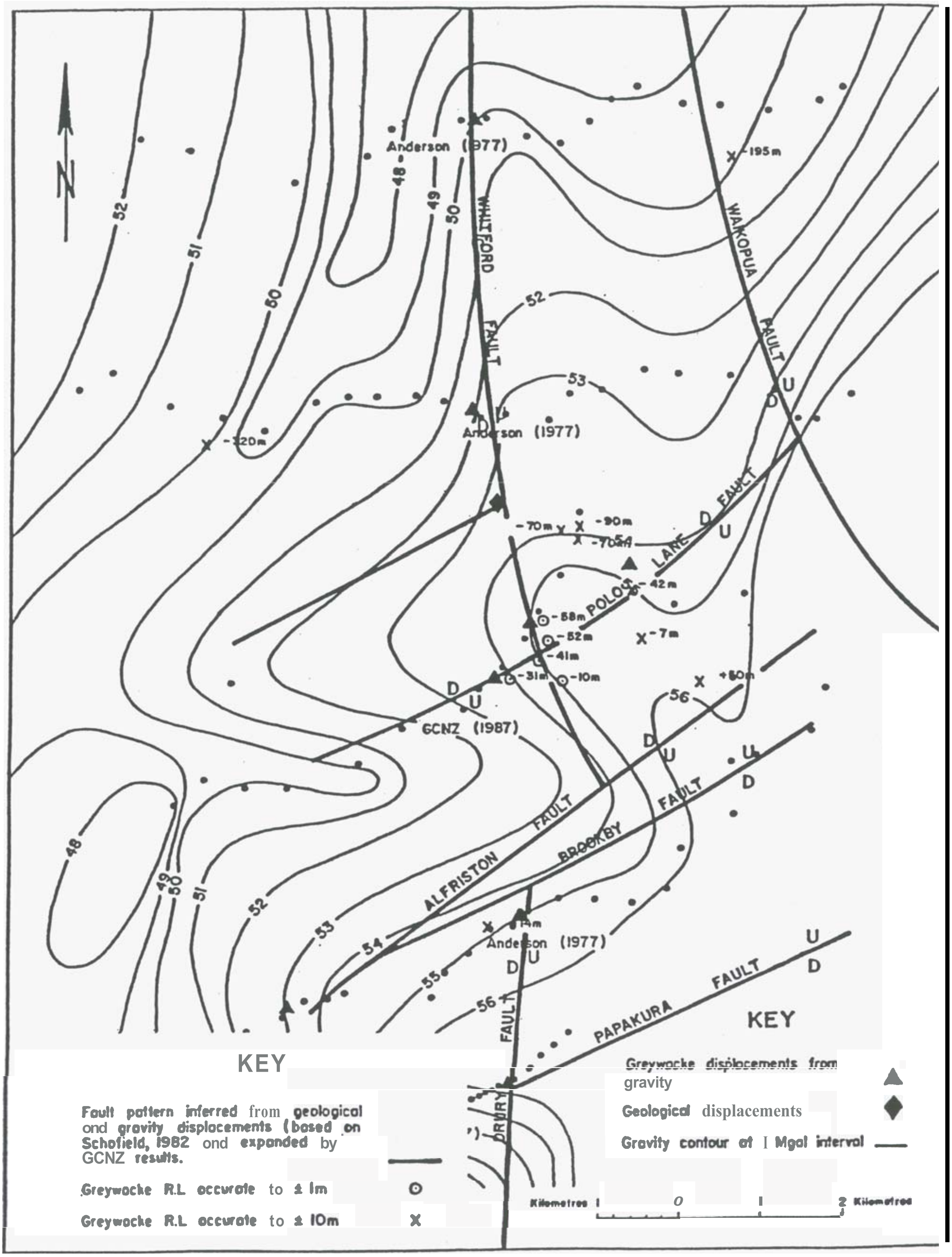
Anderson (1977)
WHITFORD FAULT
WAIKOPUA FAULT
Anderson (1977)
POLO LANE FAULT
GCNZ (1987)
ALFRISTON FAULT
BROOKBY FAULT
Anderson (1977)
PAPAKURA FAULT
DRURY FAULT
KEY
KEY
Fault pattern inferred from geological and gravity displacements (based on Schofield, 1982 and expanded by GCNZ results.
Greywacke R.L. accurate to ± 1m
Greywacke R.L. accurate to ± 10m
Greywacke displacements from gravity
Geological displacements
Gravity contour at 1 Mgal interval
Kilometres 1 0 1 2 Kilometres

Figure 3

Warm, boron-rich water rises rapidly from depth through the zone of high vertical permeability associated with intensely fractured rocks at the intersection point of two faults, When the rising water encounters the extremely impermeable Waitemata sediments which act as a capping rock, it is diverted laterally. The preferred route for this lateral flow appears to be into the superficial fractures of the basement block which is downthrown on the Polo Lane Fault and upthrown on the Whitford Fault (that is, the NE block relative to the intersection point). Drillholes tapping this NE sector of the greywacke aquifer yield large quantities of warm water.

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