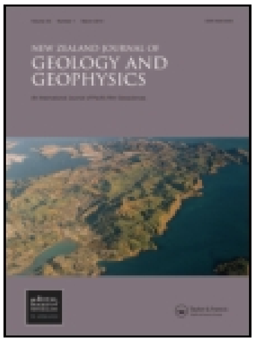

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Short communication

A gravity survey of the Wharekauhau Thrust, Palliser Bay, New Zealand

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Abstract A gravity survey undertaken at Wharekauhau, Palliser Bay, New Zealand, determines the geometry of the Wharekauhau Thrust. Gravity observations made along two profile lines perpendicular to the strike of the fault, enable two-dimensional models of the thrust and Miocene–Quaternary basin sediments to be constructed. Observed gravity is best modelled by a thrust dipping 25 ± 10° to the northwest over the depth interval 0–1 km. A second fault of steeper but unresolvable dip is modelled in the region of the Wharepapa River, across which Miocene–Quaternary sediments are downthrown c. 100 m to the east. The basin sediments produce a 25 mgal residual gravity low relative to the surrounding greywacke basement rock, which suggests a thickness of 1800 ± 500 m, similar to previously published estimates.

Keywords Wharekauhau Thrust; Wairarapa Fault; gravity survey

INTRODUCTION

During the late Holocene, predominantly strike-slip displacement occurred along the main branch of the Wairarapa Fault (Fig. 1) between Lake Wairarapa and Mauriceville (Grapes & Wellman 1988). Farther south, this deformation is partitioned into dominantly strike-slip displacement on a western splay that juts into the Rimutaka Range along the Orongorongo River valley, and dominantly dip-slip displacement on the Wharekauhau Thrust, an easterly splay that extends along the southeastern flank of the southern Rimutaka Range. Gravity surveys along two parallel traverses perpendicular to the estimated strike of the Wharekauhau Thrust allow models of the fault and Wairarapa Basin within this region to be constructed (Fig. 2). From these, a greater understanding of the interrelationship between the two southerly splays is obtained.

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TECTONIC SETTING

The Wairarapa Fault is one of six major faults of the North Island Dextral Fault Belt (Beanland 1995), a zone of dominantly dextral strike-slip faults that lie within, and strike parallel to, the Australia-Pacific plate boundary along the southern North Island of New Zealand (Fig. 1). The M+8 earthquake in 1855 caused surface rupturing along the Wairarapa Fault for a distance of at least 148 km (Grapes 1999). Between Mauriceville and the southwestern corner of Lake Wairarapa, well-defined fault scarps are observable along the eastern Rimutaka Range front. Farther south, the fault cuts into the Rimutaka Range. A series of spurs extending from the Rimutaka Range into the Orongorongo River valley are dextrally displaced by what appears to be an active strike-slip fault (Begg pers. comm.). A large reverse component of the Wairarapa Fault splays out to the east at the southwestern end of Lake Wairarapa, forming the Wharekauhau Thrust (Grapes & Wellman 1993).

The surface trace of the Wharekauhau Thrust is recognised as the junction between highly deformed Mesozoic Torlesse greywacke of the Rimutaka Range and

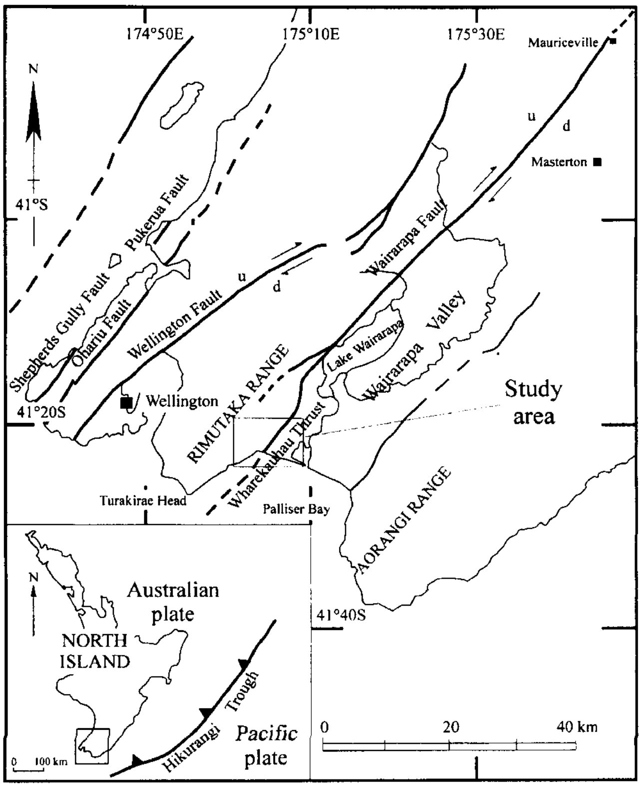

Fig. 1 The lower North Island of New Zealand, showing the major faults of the North Island Dextral Fault Belt, including the Wairarapa Fault and the associated Wharekauhau Thrust.

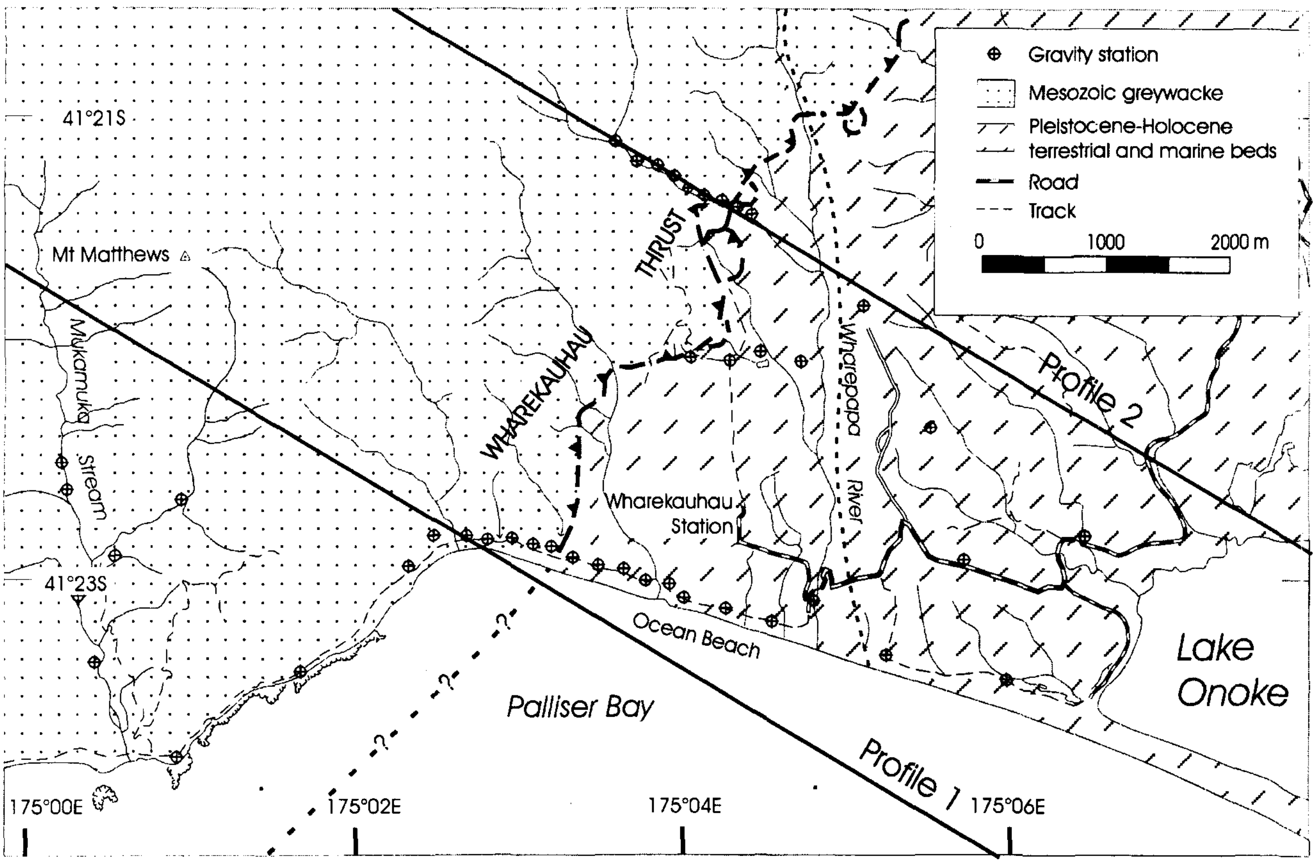

Fig. 2 General geology of the Wharekauhau area, including the Wharekauhau Thrust trace and the inferred position of the Wharepapa River channel fault (bold dashed lines). Also shown are the locations of all gravity observations and the two profile lines to which these were projected (shown in Fig. 3).

Pleistocene–Holocene terrestrial and marine sediments of the Wairarapa Basin to the east (Fig. 2). Folds and thrust faults mapped within the Pleistocene–Holocene marine sediments immediately east of the thrust (Bloom 1951; Grapes & Wellman 1988; Begg & Mazengarb 1996) suggest that a greater component of Pleistocene–Holocene uplift and shortening has occurred along this section of the fault than on the main branch farther north. Vertical displacements attributable to the 1855 earthquake decrease northeast along the fault, from 2.7 m, where the Wharekauhau Thrust meets the Palliser Bay coast, to 0.5 m c. 88 km inland. The 1855 earthquake caused greatest observable uplift at Turakirae Head (Fig. 1), where the lowest stranded beach ridge lies 6.5 m above the present-day beach ridge. Mt Matthews, the highest point of the southern Rimutaka Range, and Turakirae Head, both lie on an axis that parallels the surface trace of the Wharekauhau Thrust, which suggests an interrelationship between maximum uplift of the Rimutaka Range and fault movement on the thrust.

GRAVITY REDUCTION AND MODELLING

Gravity observations are reduced to Bouguer anomalies in the standard manner using the 1930 International Gravity Formula (Reilly 1972). A regional gravity field is derived by interpolation between gravity measurements on Torlesse basement rock listed within the Institute of Geological & Nuclear Science's master file of New Zealand gravity observations (Woodward 1982). Models for the two profiles were produced from the residual gravity anomalies using the Grav 2D™ modelling program. For added control on the shape of the residual gravity anomaly at the northwestern ends of the two profiles, gravity observations taken from the Institute of Geological & Nuclear Science's master file of New Zealand gravity observations are included. There are no drillholes in the immediate vicinity of Wharekauhau suitably deep enough to provide density values for the basin sediments. For this reason, the four-layer density distribution model used is the same as that adopted by Woodward & Hicks (1978) in their residual gravity model of the entire Wairarapa Basin.

Special attention is paid to limiting uncertainties produced from elevation measurements. Gravity station elevations were measured using both an infrared ranging theodolite where possible and aneroid barometers (McClymont 1998). The residual gravity anomaly uncertainties are calculated to two standard deviations from each mean (95% confidence level).

Geometrically simple models that best fit the observed gravity values, within error limits, are presented in Fig. 3 (profiles 1 and 2). The Wharekauhau Thrust is shown to dip at c. 25° to the northwest for both profiles. This gentle dip is well constrained (±10°) for the depth interval 0–1 km for both profiles, but larger uncertainties in gravity values measured toward the northwestern ends of the profiles do not discount the possibility of a dip-varying fault plane at a

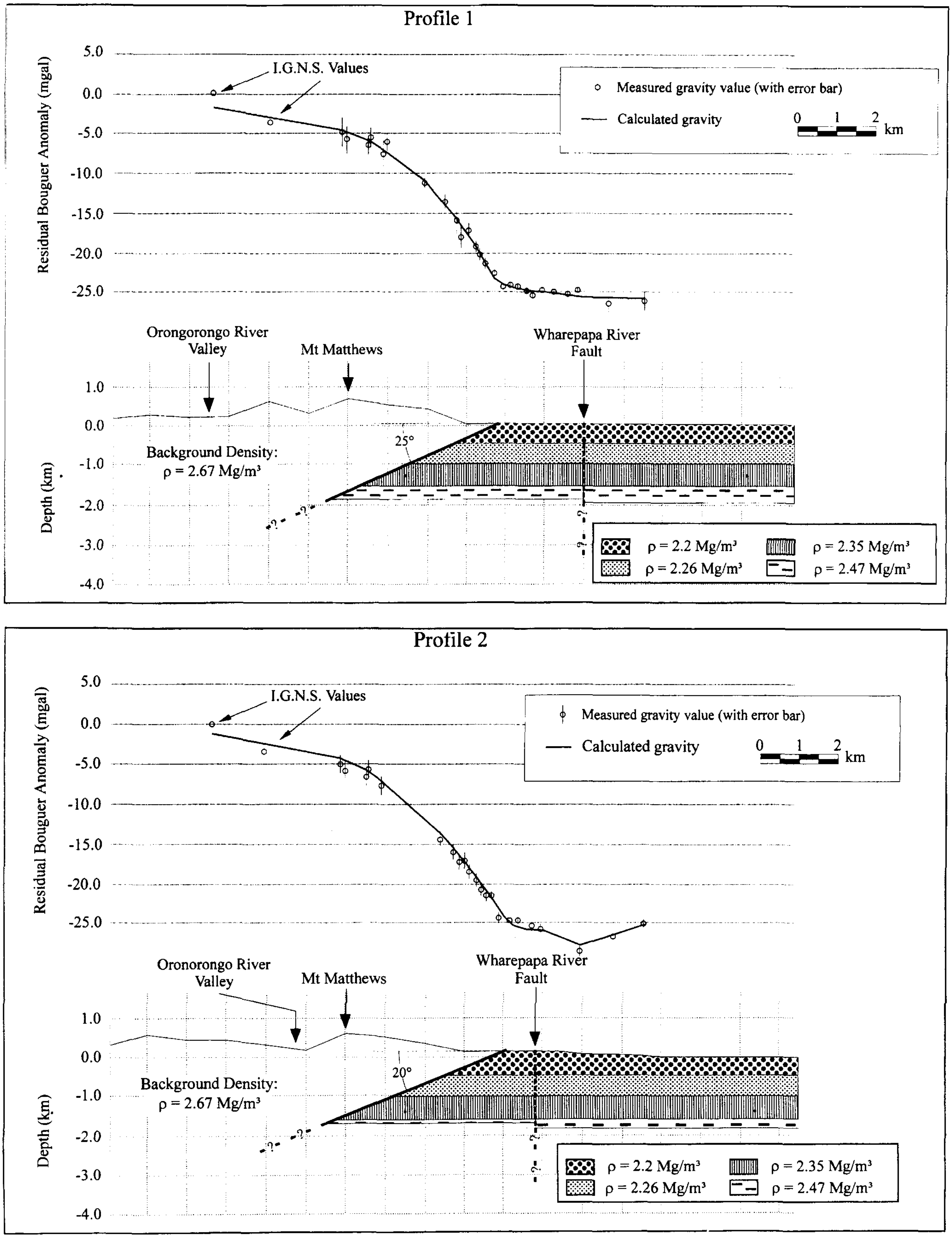

Fig. 3 Profiles 1 and 2. These diagrams show the best fit two-dimensional model for gravity observations made along each of the profiles. A four-layer density distribution model is used for the Cenozoic basin sediments, and gravity is calculated for these relative to a background density of 2.67 Mg/m^3 (Mesozoic greywacke). Because it does not run perpendicular to the gravity profiles, the Wharepapa River Fault is positioned relative to the projected profile positions of the nearest gravity observations. Also shown is topographic height sampled at 1 km intervals along each of the profiles.

greater depth. Darby & Beanland (1992) used a forward elastic dislocation modelling technique to demonstrate that the Wairarapa Fault is a listric structure and that, in the upper crust, the fault has a near-vertical dip. If the Wharekauhau Thrust has a constant dip (25°), it will intersect with the Wairarapa Fault at c. 4 km depth beneath the Orongorongo River valley.

Gravity observations made east of the Wharepapa River (Fig. 2, 3) are satisfied by a slight thickening (c. 100 m) of the sediment body east of the river. A fault modelled in the vicinity of the Wharepapa River provides a mechanism by which this thickening may occur. This interpretation is consistent with those made by Kingma (1967) in his geological map of the region, Rollo (1992) in a geophysical study of the region, and Hollands (1998) who noted Quaternary beds to be offset downward to the east within the Wharepapa River. The lack of high quality data over this section of the profile prevents accurate modelling of the attitude of the fault plane, and a vertical fault is adopted.

The Miocene–Quaternary basement sediments produce a 25 mgal residual gravity low relative to the surrounding basement greywacke. Depth to basement is not well constrained by gravity observations alone, due to uncertainties in the estimated regional gradient and the density distribution model used. This prevents an estimate for the thickness of the sedimentary basin of any better than 1800 ± 500 m, but this is similar to previous models produced for the area (e.g., Woodward & Hicks 1978; Rollo 1992). No local magnetic or seismic data were available at the time of study to better constrain the model.

CONCLUSIONS

The results of this survey show that the Wharekauhau Thrust is a low-angle (c. 25°) reverse fault. The low-angle nature of the thrust also suggests that, unlike the Wairarapa Fault which is thought to fracture the entire crust from the surface to the subduction interface (Darby & Beanland 1992), the thrust is a shallow feature that unites with the Wairarapa Fault in the upper crust. Although only a shallow feature, the thrust parallels an axis of maximum Pleistocene–Holocene uplift for the southeastern Rimutaka Range, and for this reason uplift of the southeastern Rimutaka Range is likely to coincide with reverse movement on the Wharekauhau Thrust.

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