Supplementary Data

Seismic characterisation of the Te Puninga fault, Hauraki plains, New Zealand

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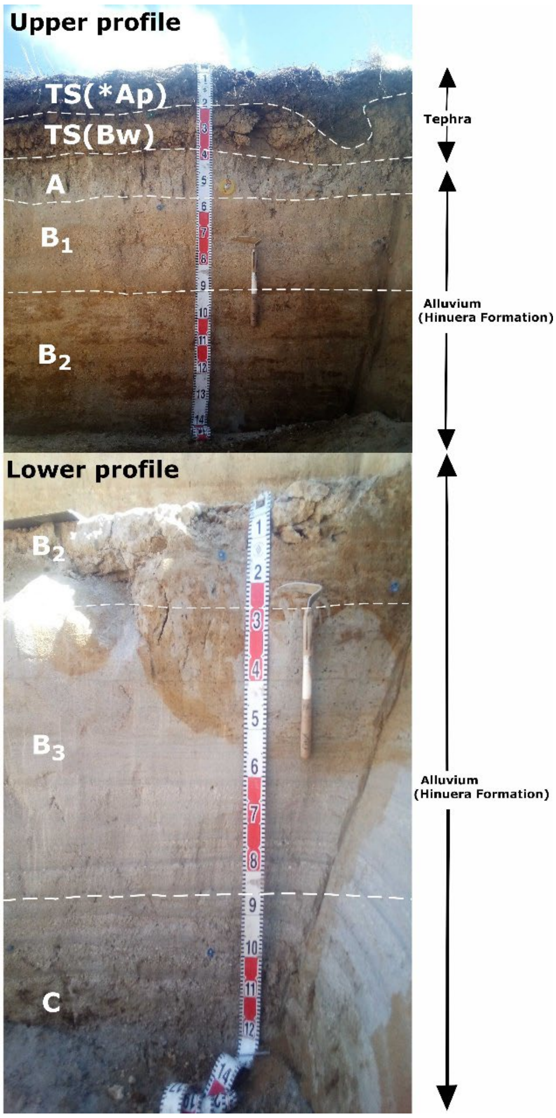
Ryland – north wall



TS(*Ap) - 0-17 cm. Silty sand; dark brownish black; friable, weakly pedal, brittle peds; abundant roots; moderately allophanic (NaF test); distinct wavy boundary.

TS(*Bw) - 17-30 cm. Silt; yellowish brown; friable, apedal earthy; many roots, some large root channels; strongly allophanic; indistinct smooth boundary.

A - 30-58 cm. Fine to medium sand; blocky to prismatic; >90% low chroma colours, ~5% MnO_2 concretions; strong peds; few roots, few large root channels ~3 cm; smooth diffuse boundary.

B_1 - 58-90 cm. Fine to medium sand with some fine pumice lapilli; less coherent than A; a few deep root channels containing Ap horizon material; ~40% orange mottles, 60% low chroma colours; indistinct smooth boundary.

B_2 - 90-160 cm. Medium sand with coarse sand and medium pumice lapilli lenses; redox segregations, ~75% orange and ~25% low chroma, <5% MnO_2 concretions; strongly reduced (positive Childs' test); indistinct smooth boundary.

B_3 - 160-225 cm. Medium sand with coarse sand and lenses of medium pumice lapilli; thin horizontal heavy mineral (designated mafic hereafter) beds; 50% orange staining and 10% MnO_2 concretions in the upper 30 cm; strongly reduced; indistinct smooth boundary.

C - 225-260 cm. Coarse sand with 3-5 cm thick fine to medium lapilli pumice beds; mafic mineral crossbeds (1-2 mm thick) present; strongly reduced.

Notes

* Ap and Bw are soil horizon designations from Clayden and Hewitt (1989); textural and other terms follow Milne et al. (1995). TS stands for Top Soil. Upper landscape soils at Arnold and Ryland sites are representatives of the Waihou and Te Puninga series (Wilson 1980), respectively, and are Orthic or Impeded Allophanic Soils (Hewitt 2010); lower landscape soils are representatives of the Waitoa series (Wilson 1980) and are Orthic Gley Soils (Hewitt 2010).

Stratigraphy is based on field observations and Hume et al. (1975), Wilson (1980), Lowe (1988, 2023), Manville and Wilson (2004), Leonard et al. (2010), and Persaud et al. (2016).

Note that Unit 1 not on this stratigraphic section of the trench

Detail of stratigraphy with tephras, Ryland - south wall

TS(Ap1) - 0-37 cm. Sandy loam; dark greyish brown; many strong polyhedral peds; common roots; indistinct wavy boundary. (S unit on log)

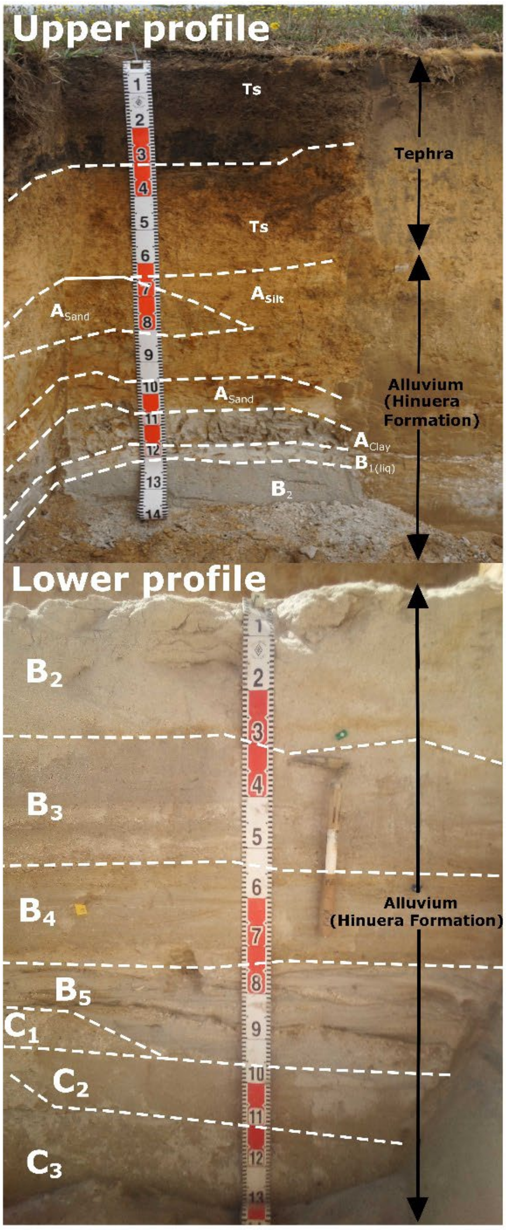
TS(Ap2) - 37-50 cm. Sandy loam; dark olive brown; Many strong polyhedral peds; common roots with brown mottles; below 46 cm, orange brown silty mottles occur; abrupt wavy boundary. (S unit on log)

1 (contains Kh/Tp) 50-61 cm. Medium sand; grey with brown mottles; intermittent orange-grey silt (Kaharoa tephra, Ka) overlying a white discontinuous pumice lapilli layer <5 mm thick (Taupo tephra, Tp); abrupt wavy boundary. (S unit on log)

A1 - 61-85 cm. Fine white sand with some fine pumice lapilli, fining upwards; 5% mafic minerals; distinct smooth boundary.

A2- 85-150 cm. Coarse sand with <5% fine pumice lapilli; <5% orange mottles; ~1 mm-thick beds of mafic minerals; coarse sand and pumice lapilli beds dipping steeply westward; thin peat layer at depth of 140 cm.

Arnold - north wall



TS(Ap) 0-30 cm. Silt loam; grey yellowish brown (10YR 4/2†); apedal, earthy; basal part mixed brownish-black, potentially from ploughing; weakly allophanic; distinct wavy boundary.

TS(Bw) 30-65 cm. Silty sand; yellowish brown, <5% orange mottles; friable; strongly allophanic; diffuse smooth boundary.

A1

A_{Sand} 65-85 cm and 95-107 cm. Coarse sand and pumice lapilli; yellowish brown, ~20% orange mottles; spatially variable – occurs as both a lens in profile and as a horizontal layer.

A_{Silt} 65-95 cm. Silty sand with rare pumice lapilli; 40% orange mottles, 30-40% low chroma colours; indistinct boundary to lower A_{Sand} layer (see photo).

A2

AClay 107-115 cm. Clayey silt; 80% low chroma colours; blocky; abrupt smooth boundary.

$B_{1(liq)}$ 115-120 cm. White, fine sand-silt layer; possible liquefaction (liq) or sand blow; abrupt smooth boundary.

B_2 120-186 cm. Medium to coarse sand with coarse sand and fine pumice lapilli beds; pale grey with ~5% orange staining; indistinct wavy boundary.

B_3 186-197 cm. Medium sand with fine mafic mineral beds; pumice lapilli lenses <4 mm thick; grey with 10% orange staining and 20% MnO_2 concretions; smooth indistinct boundary.

B_4 197-216 cm. Fine to medium sand with 30% mafic minerals; fine, rhyolitic sand lens pinching out; coarse grained interbeds; grey with 40% orange staining, distinct horizontal pattern; smooth indistinct boundary.

B_5 216-236 cm. Fine sand with some pumice lapilli clasts (~3 mm) and fine mafic sand crossbedding; Medium pumice lapilli lenses; grey with <5% mottles; smooth distinct boundary.

C_1 Pinching out on left of photo. Coarse sand to gravel with medium pumice lapilli; grey; abrupt smooth boundary.

C_2 236-250 cm. Coarse sand; dark grey; 30% mafic minerals; well sorted matrix with lenses of larger, medium pumice lapilli clasts; strongly reduced; distinct wavy boundary.

C_3 250 cm. Fine to coarse sand, poorly sorted, contains fine to medium pumice lapilli; dark grey; variable mafic mineral concentrations; strongly reduced.

†Munsell colour notation

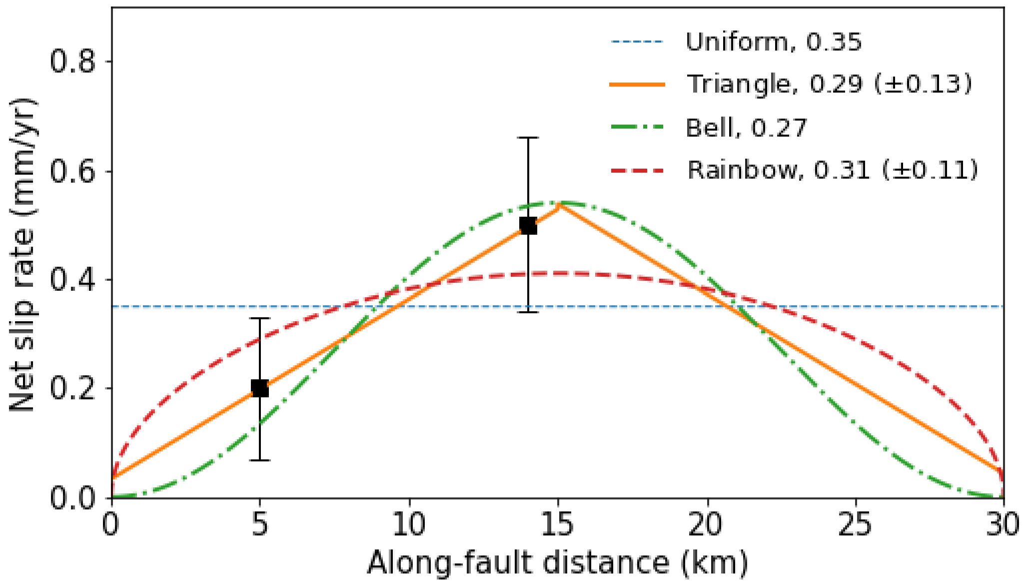
S2-OxCal model code for Hinuera Surface age…

Oxcal code: Plot()

```
{
 Curve("SHCal20","shcal20.14c");
 Combine("Hinuera")
 {
 R_Date("Wk52552", 19773, 46);
 R_Date("Wk52554", 19963, 47);
 };
 R_Date("Wk52555", 20705, 50);
};
Plot("x")
{
 Sequence("x")
 {
 Boundary("base");
 Phase("x")
 {
 Curve("SHCal20","shcal20.14c");
 R_Date("Wk52552", 19773, 46);
 R_Date("Wk52554", 19963, 47);
 R_Date("Wk52555", 20705, 50);
 };
 Boundary("post-peat");
 };
};
Plot("tau")
{
 Sequence("x")
 {
 Tau_Boundary("base");
 Phase("x")
 {
 Curve("SHCal20","shcal20.14c");
 R_Date("Wk52552", 19773, 46);
 R_Date("Wk52554", 19963, 47);
 R_Date("Wk52555", 20705, 50);
 };
 Boundary("post-peat");
 };
}
```

S3-Uncertainty associated with Te Puninga Fault slip rate

To further assess uncertainty on the average net slip rate estimated along the Te Puninga Fault presented in the main text, we have fitted the two data points to different models. These models are uniform (or mean of the estimated net slip rates), triangle (Manighetti et al. 2005), bell (or a raised cosine function; note this is different to the main text model, as in that one we forced the curve to fit the average values on those points), and rainbow-shaped (or sinesqrt) functions (Biasi and Weldon 2006; Thingbaijam et al. 2022). The average net slip rate estimates are annotated on the plot below (in the legend, the 2-sigma estimates are given in the brackets). All these models capture the data (square dots with error bars) within the error (2-sigma) bounds, the uniform model does not as it overestimates the net slip rate closer to the fault edge. Excluding the uniform model, there is reasonable agreement that the average net slip rate is < 0.3 mm/yr. The values of the main text of 0.25 mm/yr (95% CI limits of 0.15–0.37 mm/yr) are similar to the values estimated here. At this stage we regard the main slip rate value in the text as reasonable for this preliminary assessment until we can add more slip rate values along the fault to be able to properly assess what model better fits the Te Puninga Fault slip rate.



References

Biasi GP, Weldon RJ, II. 2006. Estimating surface rupture length and magnitude of paleoearthquakes from point measurements of rupture displacement. Bulletin of the Seismological Society of America. 96(5):1612–1623. doi:10.1785/0120040172.

Clayden B, Hewitt AE. 1989. Horizon notation for New Zealand soils. Manaaki Whenua Press, Lincoln. 30 pp.

Hewitt, AE. 2010. New Zealand soil classification. Landcare research science series, (1); 136p. doi:10.7931/DL1-LRSS-1-2010

Hume TM, Sherwood AM, Nelson CS 1975. Alluvial sedimentology of the Upper Pleistocene Hinuera Formation, Hamilton Basin, New Zealand. Journal of the Royal Society of New Zealand. 5: 421–462

Leonard GS, Begg JG, Wilson CJN,. and Leonard, G.S., 2010. Geology of the Rotorua area. Lower Hutt, New Zealand: GNS Science.

Lowe, DJ. 1988. Stratigraphy, age, composition, and correlation of late Quaternary tephras interbedded with organic sediments in Waikato lakes, North Island, New Zealand. New Zealand Journal of Geology and Geophysics. 31(2): 125-165

Lowe DJ. 2023. Soils and landscapes of the Hamilton Basin and part South Waikato area − a summary. Earth Sciences group, School of Science, University of Waikato, Hamilton. 51 pp. https://www.researchgate.net/publication/369998946_Soils_and_landscapes_of_the_Hamilton_Basin_and_part_South_Waikato_area_-_a_summary

Manighetti, I., Campillo, M., Sammis, C., Mai, P.M. and King, G., 2005. Evidence for self-similar, triangular slip distributions on earthquakes: Implications for earthquake and fault mechanics. Journal of Geophysical Research: Solid Earth, 110(B5).

Manville V, Wilson CJN. 2004. The 26.5 ka Oruanui eruption, New Zealand: a review of the roles of volcanism and climate in the post-eruptive sedimentary response. New Zealand Journal of Geology and Geophysics 47, 525–547.

Milne D, Clayden B, Singleton P, Wilson A. 1995. Soil Description Handbook. Revised edition. Manaaki Whenua Press. 157 pp.

Persaud M, Villamor P, Berryman KR, Ries W, Cousins WJ, Litchfield N, Alloway BV. 2016. The Kerepehi Fault, Hauraki Rift, North Island, New Zealand: active fault characterisation and hazard. New Zealand Journal of Geology and Geophysics. 59: 117–135.

Thingbaijam KKS, Van Dissen RJ, Shaw BE, Gerstenberger MC. 2022. Average coseismic slip profiles. Lower Hutt (NZ): GNS Science. 33 p. (GNS Science report; 2021/24). doi:10.21420/S6ED-JN06.

Wilson AN. 1980 Soils of the Piako County. New Zealand Soil Survey Report 39.