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## KAINUI SILT LOAM : HOW THE LEOPARD CHANGED ITS SPOTS

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The Kainui silt loam occurs on low rolling hills in the northern part of the Hamilton Basin, and is well expressed in Hamilton City. It typically has the following profile features (Fig. 1):

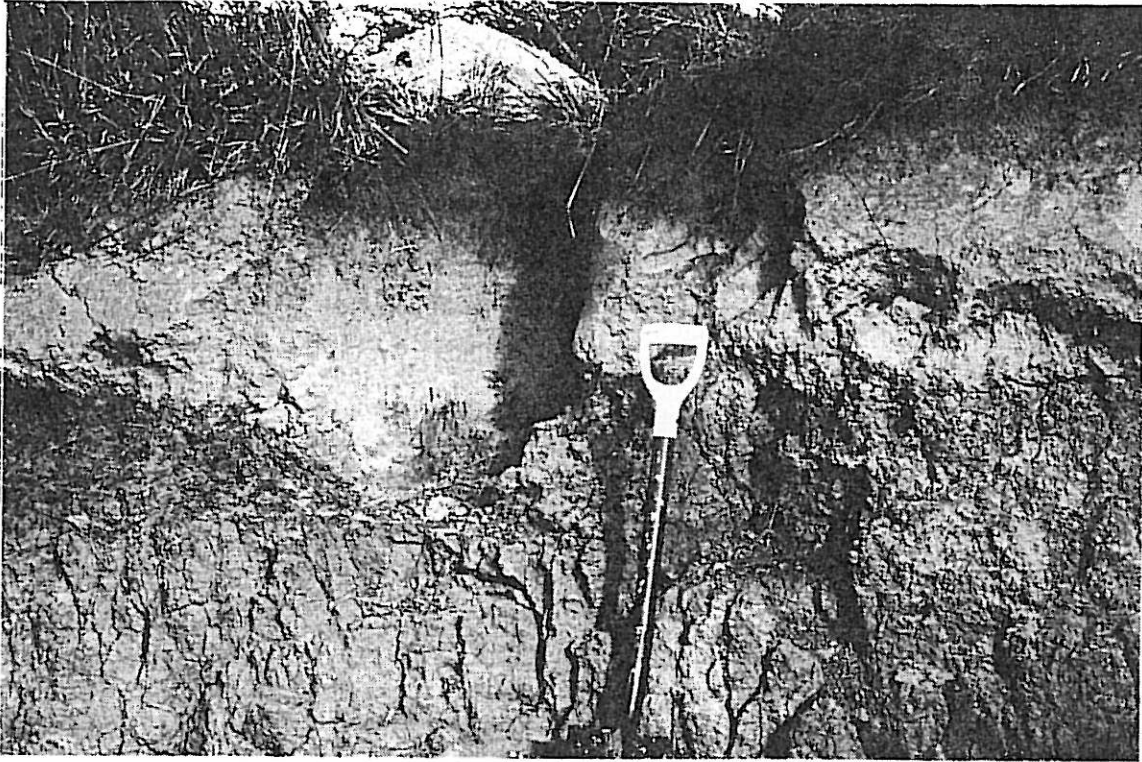
Ap	15–20 cm [average thickness range]	Very dark greyish brown (10YR 3/2) silt loam; friable; moderately to strongly developed fine and medium granular structure, occasionally with fine crumbs and nuts; many roots and pores; often much mixing at distinct to indistinct, usually irregular boundary;
Bw(f)	10–40 cm	yellowish brown (10YR 6–4/4) to brown (10YR 5/3) silt loam to silty clay loam, with occasional sandy inclusions in lower half of horizon; friable to firm, slightly plastic, compact and brittle when dry; weakly, occasionally moderately developed fine, medium, and coarse nutty structure, but appearing near massive in place when dry; many fine and medium, black Mn concretions, often with mottles; distinct but mixed boundary;
2bBt1	10–40 cm	strong brown (7.5YR 5/6), sometimes with very dark brown (7.5YR 2/2) to yellowish red (5YR 5/8) mottles, clay loam to clay; firm to very firm, plastic and sticky; moderately developed medium (coarse in place) blocky structure; some clay skins on peds; distinct to diffuse boundary;
2bBt2	20–60 cm	strong brown (7.5YR 5/8) to yellowish red (7.5YR 6/6–8) clay; firm, very plastic and very sticky; weakly developed coarse blocky or prismatic structure.

The genesis of the Kainui silt loam, especially the identification of its parent materials, has been of interest since the soil was first described and mapped in the benchmark Waipa County survey in the early 1930s. The soil (not called the Kainui then) was originally described as being formed from Hamilton Ash, but the recognition of two 'storeys' to the profile — the silty Ap and Bw horizons form the upper storey, about 0.5 m thick, and the clayey 2bBt1 and 2bBt2 horizons the lower storey — raised the question as to why these upper and lower parts were different.

An early suggestion was that podzolisation was somehow responsible, the 2bBt1 horizon (a paleosol on Hamilton Ash) then being regarded as what we might today call a spodic horizon. A variation on this idea was that the whole profile was formed in Hamilton Ash, but that the upper part differed from place to place because of differences in rainfall (as we shall see, this idea was partly right with regard to rainfall).

However, it was the difference in texture that pointed to a possibly better option: a coarser-textured top commonly indicates the addition of new (less weathered) material to a soil profile. Thus, two main hypotheses were put forward. The first was that the upper part of the profile represented a cover bed of loess deposits blown on the Hamilton Ash-covered hills, during the last glaciation: their silty, compact nature, especially when dry, seemed not too dissimilar from loess deposits elsewhere in New Zealand (Fig. 1).

The second hypothesis was that the cover bed materials represented young volcanic ash, or tephra, deposits, not loess, overlying the Hamilton Ash. This suggestion was helped by the fact that such composite tephra deposits, originally called the 'Mairoa and Tirau ash beds', had been mapped in



*Figure 1. Kainui silt loam profile at Rototuna, Hamilton, showing the composite mantle of late Quaternary ( $\leq$  c. 50 000 years old) tephra (above the spade handle) overlying a paleosol on Hamilton Ash. These upper and lower storeys are quite obvious in this dry section, but are not so easy to distinguish in moist soil pits.*

many other parts of the Waikato region *except* in the northern Hamilton Basin: in other words, if the cover deposits were not young tephra deposits, then their absence required explanation (Professor McCraw used to refer to these 'missing' tephra deposits as "the hole in the ashes"). However, the main reason the tephra suggestion was initially discarded in favour of the loess one was that the cover bed deposits did not look much like the yellowish-brown, friable, allophanic, young tephra deposits found elsewhere, particularly to the south and east of Hamilton, and they almost always showed a negative response to the NaF test for allophane. It is important to appreciate here that at this time the prevailing model for tephra-derived clay mineral genesis followed a time-based weathering pathway whereby allophane formed initially in 'young' deposits and then over time transformed into halloysite in 'old' deposits. Thus, the non-allophanic, halloysitic nature of the cover bed materials was seen to preclude them having formed from 'young' tephra deposits.

So, what is the identify of the upper storey deposits in the Kanui silt loam? It turns out that most of these materials are the remains of young tephra deposits made up of many individual rhyolitic and andesitic layers, each a few millimetres to centimetres in thickness, that were erupted from six distant volcanoes over the past c. 50 000 years, namely the Tuhua [Mayor Island], Okataina, Maroa, Taupo, Tongariro, and Taranaki volcanoes. A few of the tephra were able to be identified (correlated) in the cover bed itself using mineralogy to characterise them (e.g., Rotoehu Ash) but the best record was found in lakes adjacent to the hills on which the Kainui soils occur. Cores taken from such lakes showed numerous thin tephra layers preserved in the peaty sediments — there was no "hole in the ashes". In the Kanui soil, the tephra layers have been weathered and blended together by soil-forming processes, especially bioturbation, so that their original tephric character has been almost completely masked: the leopard had changed its spots. At sites not too far to the south of Hamilton, where the equivalent tephra cover bed deposits are usually 1 m or more thick, forming Ohaupo or Otorohanga soils, some of the tephra layers are of sufficient thickness to be recognisable in the profiles (Fig. 2), but as Hamilton is approached, they have all 'telescoped' down to only about 0.5 m in total thickness. Where the cover bed deposits have been more or less entirely lost through erosion, the exhumed Hamilton Ash materials form the main soil parent materials, giving rise to the Hamilton or Naikē series with which the Kanui is commonly associated (Fig. 2).

As well as mixing processes, the shallow cover bed deposits have experienced wetting and drying because of restricted drainage due to the underlying clayey paleosol on Hamilton Ash (marked by the ubiquitous Mn concretions in the lower part of the Bw horizon) and to the short seasonal moisture deficit that often occurs north of Hamilton. This, together with a moderate leaching regime because of only modest rainfall, has reduced the loss of Si through drainage, which in turn favours the formation of halloysite instead of allophane. At this point it should be noted that such a genesis is currently acceptable because of a recent switch in thinking about the weathering pathways for tephra-derived clays: halloysite can apparently form quite independently of allophane mainly depending on whether conditions favour high or low concentrations of Si in soil solution.

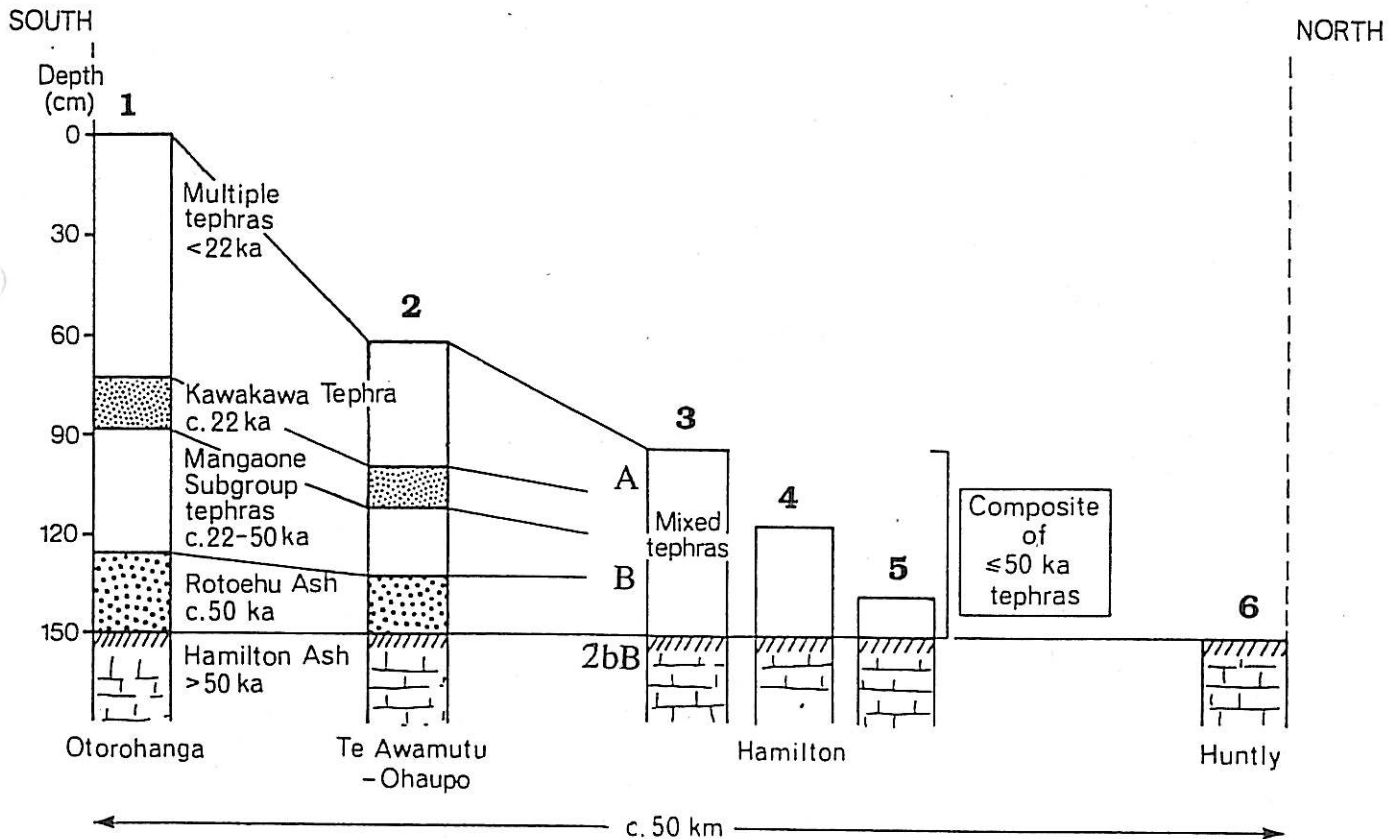


Figure 2. Relationship of tephra parent materials and soils on low rolling hills along a generalised south-north transect from Otorohanga through Hamilton to Huntly. Note that thin late Quaternary tephras are present at non-eroded sites further north towards Auckland. Profiles: 1, Otorohanga silt loam; 2, Ohaupo silt loam; 3, 4, Kainui silt loam; 5, Hamilton silt loam; 6, Naike clay. Profile 3 is that shown in Fig. 1; ka = 1000 years BP.

Thus, the Kainui silt loam is a two-storeyed soil, the upper storey comprising a composite cover bed mantle of multiple, intermixed tephra layers deposited since c. 50 000 years ago, the lower storey a buried paleosol on the much older Hamilton Ash. The imprint of soil-forming processes on the solum has been of sufficient magnitude that the soil parent material's true identity was successfully hidden for some time.

Also rather uncertain was the classification of the Kainui soil in the old New Zealand system. This was problematic because the soil does not fit readily with other soils developed from tephra deposits. Being non-allophanic, it was excluded from the yellow-brown loam group. The best alternative, conceptually, was a brown granular loam, but distinction from another option, a yellow-brown earth, was not really as clear as might be imagined. Therefore, one suggestion was to classify the Kainui soil as an intergrade, namely a composite yellow-brown earth over brown granular loam, in recognition of its two-storeyed nature. In the new New Zealand soil classification, it probably fits into the Mottled-Acidic Orthic Granular Soils. In terms of Soil Taxonomy, it is probably a Hapludult.

Note added in 2011: classification in NZSC (3rd ed.) = Buried-granular Yellow Ultic Soil (Hewitt 2010).