Chronology, accumulation rates and geomorphic implications of Birdlings Flat Loess, Banks Peninsula, Canterbury, New Zealand

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Introduction

Background:
Better chronologies for the multilayered loess deposits of the east coast of the South Island, New Zealand would allow:
1) Models of links between climate and loess accumulation events to be tested;
2) Temporally constrained proxy climate records to be generated;
3) Spatial distribution of loess sheets to be used to reconstruct landscape history.
The existing loess chronology is based on:
1) A single, often microscopic tephra marker (Kawakawa tephra, 26.5 k cal yr BP from Taupo Volcanic Zone) in the uppermost loess sheet;
2) A few TL and IRSL ages that are of low precision and show age reversals.

This study

Aim
To produce a detailed, cross-validated chronology for a thick loess deposit on Banks Peninsula in Canterbury, South Island, New Zealand (Fig. 1), to support palaeoclimate proxies.

Study site - Ahuriri Quarry
The lower flanks of Banks Peninsula is mantled by thick (up to 16 m) texturally-banded fine sandy to silty loess of the Birdlings Flat formation (Fig. 1). The loess incorporates secondary (pedogenic) carbonate below about 2 m depth. At Ahuriri a quarry on a ridge top exposes c. 12 m of Birdlings Flat loess. The site had also been drilled in an earlier coring programme by DSIR Soil Bureau. Stratigraphy and bulk density measurements from that core are included here.

Methods
Section logging and sampling: Each face of the quarry was logged and sampled in contiguous 10 cm-thick increments.

Tephra analysis: The emplacement horizon of Kawakawa Tephra was determined by microscopic counting of volcanic glass grains isolated in the >63 µm fraction to determine the zone of maximum concentration. Electron microprobe geochemical analysis confirmed its identification.

Radiocarbon dating: About 30 mg of fine filamentous carbonate was picked from selected samples and submitted to the Geological and Nuclear Sciences’ Rafter AMS radiocarbon laboratory in Lower Hutt, New Zealand.

OSL method at a glance
Method: Multiple Aliquot Additive (MAAD), with late light subtraction; 5 cm core or large carved block samples
Fraction: Polymeraler Fine grains (4-11mm)
Detection window: 3 mm BG39 + 3 mm Kopp 5-58 (max. transmission 410nm)
Stimulation: Infrared diodes at 30mW/cm2
Measurements: 100s shine-down at room temperature, last 20s for subtraction
Storage: 3 weeks at room temperature
Preheat: 220°C for 5 min, directly before measurement
β-irradiation: 905±90 source in Daybreak irradiator, 6 dose points up to 6xED
β-irradiation: 3 x ED source in ELSEC irradiator, 3 dose points up to 3×ED
Test measurement: SAR (4 discs) on Riso TL-Da-15, 6 dose points 0-320Gy
Fading test: Subsamples measured after 6 months storage, 5% threshold, all passed
Dosimeter: HPGe ultra low level gammaspectrometry on broad energy detector

Results and Discussion (see Fig. 2)
12m of Birdlings Flat loess at the study site accumulated in the last c. 30 ka:
• Pedogenic modification is weak indicating that the loess accumulated rapidly and essentially continuously.
• OSL and pedogenic carbonate ages are not contradictory.
OSL ages are not in agreement with the position and accepted age of Kawakawa Tephra and age reversal occurs in the lower most part of the section:
• Electron microprobe analysis supports recognition of the glass grains at 1.5 m depth as Kawakawa Tephra (26.5 k cal yr BP);
• Of the two stratigraphically reversed ages at the base of the section the c.30 ka age is preferred on the basis of the carbonate 14C ages.

Loess accumulation rate has at times been very high:
• Taking OSL ages at face value, loess accumulation rate around 18 ka at Ahuriri Quarry (Fig. 2) approaches some the highest values reported globally.

Geomorphic Implications:
• A loess source appeared close to the flanks of Banks Peninsula 30 k years ago;
• That loess source was probably the actively aggrading fan of the Waimakariri River;
• A basal age of 70 ± 15 ka for the 6 m-thick upper sheet in the silty loess at Barry’s Bay, 30 km to the east, demonstrates that Birdlings Flat loess is a locally focused accumulation, and the base of loess sheets are likely to be diachromatic.

Figure 1. Location of Banks Peninsula

Figure 2. Ahuriri Quarry data. a. Bulk density and b. core log from the Soil Bureau core showing our interpretation of loess layers of Griffiths (1975), C. Quayle section d. OSL ages, e. carbonate radiocarbon ages, f. depth and mass accumulation rates, and g. soil texture class.

Conclusions

• Birdlings Flats loess at Ahuriri Quarry was deposited since c. 30 k years ago (late MIS 3) as a rapidly accumulating proximal deposit;
• The position and accepted age of Kawakawa Tephra suggest the OSL ages are underestimates;
• The major phase of aggradation of the Waimakariri River in the last glaciation started around 30 k years ago.

References