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TWO SUB-FOSSIL FAUNAL DEPOSITS UNCOVERED NEAR CROMWELL, CENTRAL OTAGO

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This paper describes two deposits of sub-fossil fauna (predominantly moa) uncovered recently near Cromwell during the construction of new roading associated with the Clutha Valley Development hydro dam construction project. The remains are described followed by a discussion of their usefulness as indicators of palaeo-environmental changes. The term 'sub-fossil' is used in the text to denote that the stratigraphic relationships of the deposits in question suggest they predate human occupation of the area, or alternatively are of natural as opposed to cultural origin.

Sub-fossil deposits of moa skeletal material and eggshell, and the remains of other extinct fauna have been found in many areas of Central Otago within alluvial deposits, as well as in caves, under overhangs and in infilled crevices. Reminders of the prevalence of moa remains in some areas are preserved in place names such as Moa Creek (near Alexandra) and Moa Flat (near Heriot, Beattie, 1948:27). Many of the known sub-fossil fauna deposits have never been documented, but fortunately some have been described (refer Appendix 1 for locations; Murison, 1871; Hector, 1871 and 1873; Fraser, 1872; Hutton, 1874; Booth, 1874; Chapman, 1884; White, 1895; Gilkison, 1931; Oliver, 1949; Simpson, 1955; Trotter, 1970; Beck and Ritchie, 1980; Paterson, 1980; Burrows et al, 1981).

In addition to the finds described in the published reports moa bones and/or eggshell have also been uncovered, predominantly within alluvial deposits, in several locations in the Upper Clutha valley (Ritchie, 1980:45) and the Bannockburn and Kawerau river valleys (particularly in the Gibbston area). Individual finds have also been uncovered in the Cromwell gorge (Site S133/233-Caliche shelter and at Hinton's orchard), in the Little Valley near Alexandra (Ritchie, field notebook), in the Rees and Dart valleys (Beck and Ritchie, 1980), near Glenorchy (Butement diary) and in the Upper Shotover valley (P. Chandler, pers. comm.).

Overall, the known finds, together with remains uncovered in prehistoric sites such as Hawksburn (S133/5; Lockerbie, 1959; Hamel, 1978; Anderson, 1979), Owens Ferry S132/4 and the Rockfall II shelter S133/169 (Ritchie and Harrison, 1981), Dart Bridge S122/1 (Anderson and Ritchie, 1981) indicate the widespread distribution, diversity of species and longevity of existence of moas in the interior of Otago.

The Firewood Creek deposit

On 13 June 1979, Mr Trevor Connor, a Ministry of Works and Development overseer supervising earthworks on the new Cromwell bypass reported to the author that he believed two moa bones had just been uncovered by a bulldozer driver forming the road bench near Firewood Creek.

Examination revealed the bones to be a broken tibiotarsus and an intact tarso-metatasus, both in good condition. The bones had been exposed at a depth some 5 m below the original ground surface. Inspection of the area where the bones were first observed proved fruitless, but later in the day, after further bulldozing, more skeletal material was uncovered at a position 13 m south of the first findspot. This location appeared to be the source of the two bones which were uncovered initially. The contractor kindly agreed to work elsewhere while an excavation proceeded.

Excavation over two days at the location (NZMS 1 map S133, map reference 120666) by Ms A. Ross and myself revealed the remains of four moas within a loess and slope detritus infilled cleft in the schist country rock (Plate 1). (Incidentally, the moa deposit was uncovered 50 m north of site S133/424, a Chinese miners rockshelter excavated in November 1978; both sites have subsequently been totally obliterated by the highway formation).

The moas appear to have died either from injuries sustained when they fell into the 'V' shaped cleft, or starvation following entrapment. All the remains were found in a single jumbled concentration orientated in a NW-SE direction, that is, along the long axis of the cleft. The area of the cleft within which the bones were found measured 2 m long and was 60 cm wide, tapering down to about 10 cm wide at its base. The depth of the excavated deposit was 95 cm; excavation becoming progressively more difficult because the cleft inclined at an angle of 40° to the east amid large immovable blocks of schist. The mouth of the original cleft must have been considerably wider, enabling the moas to fall into it. It would have extended upward at least 4 m to the original ground surface.

A tantalising small opening at the base of the cleft suggested the possibility that further bone material might be uncovered in a lower chamber, however further manual excavation was curtailed by the large blocks of schist which formed the walls of the cleft. Considering that there was nothing to lose at this stage, the bulldozer driver was asked to try and dislodge the rocks, to facilitate access to any faunal material lodged deeper down. This manoeuvre

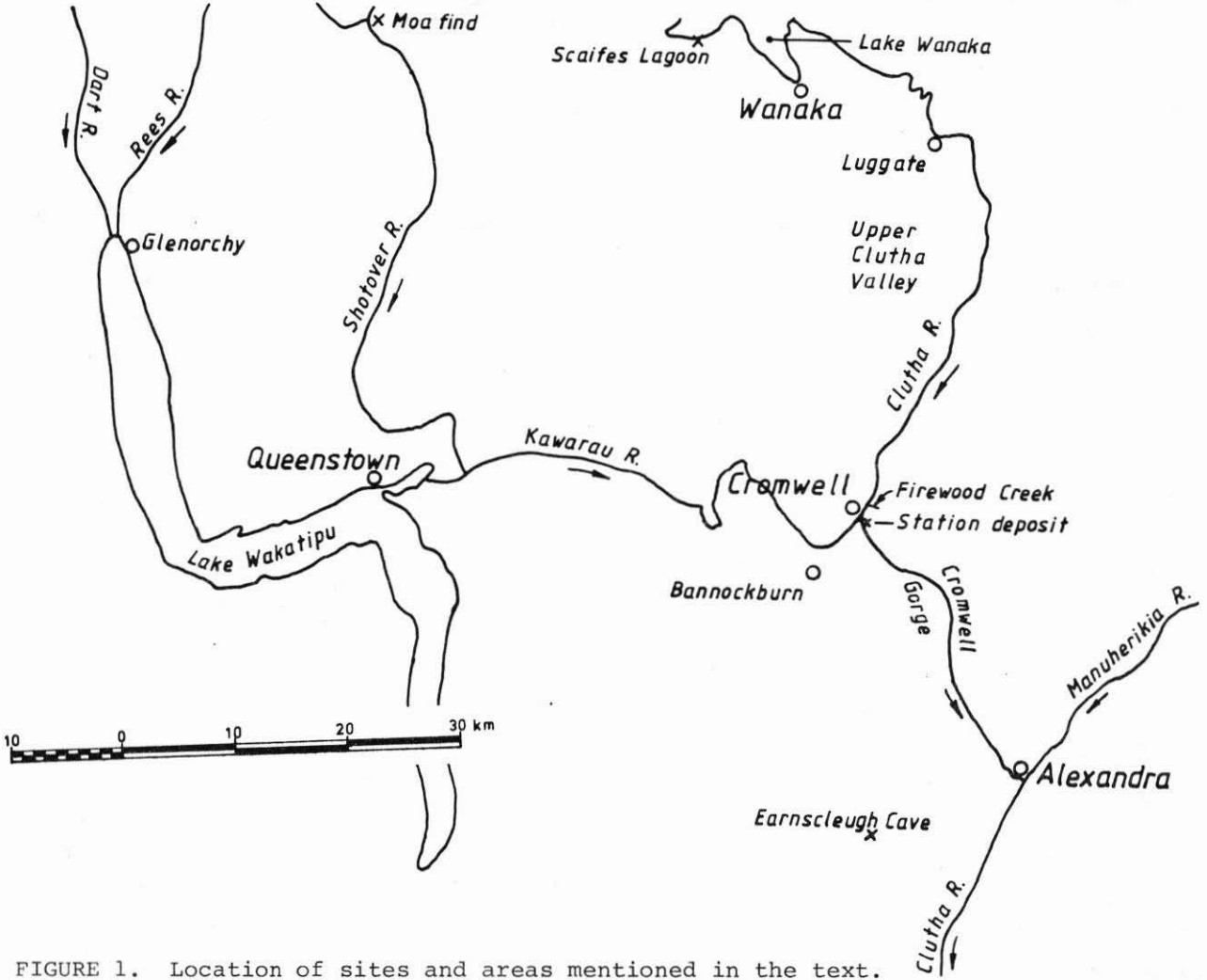

FIGURE 1. Location of sites and areas mentioned in the text.

was not entirely successful, ending with the cleft infilled with rock rubble. Although the rubble was subsequently removed by hand, access to the lower chamber was still thwarted. After due consideration of the amount of material which would have to be removed to permit access to the lower area, further excavation attempts were abandoned. It should be appreciated that there is no legal obligation for a contractor in New Zealand to delay work to enable scientific excavation of sub-fossil deposits to take place. Consequently, the onus is on archaeologists to undertake prompt and efficient recovery of remains exposed during earthworks, in order to maintain co-operation from contractors.

Analysis of the Firewood Creek remains

The bones uncovered at Firewood Creek were in sound condition, although some were incomplete or broken. A complete list is given in Appendix 2. The skeletal material was forwarded to John Darby, Assistant Director of the Otago Museum for identification. He concluded that the deposit contained the incomplete skeletons of four moas of three different species: Euryapteryx gravis (2), Anomalopteryx didiformis and Dinornis robustus (refer Appendix 2 for itemised list of skeletal parts).

The remains of the four moas were completely mixed within the cleft. It proved impossible during the excavation to differentiate one set of bones from another, in terms of specific groupings or detectable differences within the soil matrix. The juxtaposition of the moa bones suggests that all four birds were alive at about the same time and presumably the represented species coexisted in close proximity. Because of the significance of this assertion, the bones were re-examined in February 1981 by Ron Scarlett, then osteologist at the Canterbury Museum. He confirmed Darby's identifications and also identified bones of one specimen each of South Island robin, parrakeet and a lizard (not speciated); these bones were mixed within the soil matrix surrounding the moas.

Dr C.J. Burrows of the University of Canterbury Botany Department examined three samples of materials found in the same context. These revealed two species of Carex seeds, Eleocharis seeds (which according to Burrows indicate a close proximity to water), a single piece of charcoal and a basidiomycete fungus. A presumed moa coprolite found with the soil matrix was identified by Burrows as that of a domestic cattle beast. The presence of some recent material near the moa remains is quite plausible, because the cleft infill was channelled with numerous rabbit holes which are likely to have facilitated intermixing. Lateral distortion of the cleft by slip processes is believed to have caused some compaction and disturb-

ance to the deposit. Openings formed by slip-movement of the rocks surrounding the cleft may also have enabled modern material to intrude.

Dating the Firewood Creek deposit

A Euryapteryx gravis femur from the deposit was submitted for radiocarbon dating. This produced a date (NZ 5321) of -

Old T½ 1070±60 BP
New T½ 1105±65 BP
Secular corrected 1060±70 BP

A specific request was received from the project geologist to have some of the moa remains dated. Because they were buried by slip debris (loess and fragmental schist), the date provides an indication of the antiquity and rate of movement of the slip. From an archaeological point of view the date indicates the co-existence of the represented species in the Cromwell area ca. 1000 years ago.

Discussion

From the dated moa remains one can infer that the represented species were living about the time the first Polynesians are likely (on present evidence) to have entered the interior of the South Island (i.e. 750-900 A.D.). However, no direct evidence, such as cut marks, breakage patterns or artefacts, was found which indicate that the Firewood Creek moa remains were in any way associated with human exploitation or collection. Similarly, the shape of the cleft precludes the possibility that it was used as a nesting area, although the use of rock shelters and crevices for nesting has been reported in Hawkes Bay (Hartree in Falla, 1962), and in the Benmore area of the Waitaki valley (Ambrose, 1970).

Of the three species of moa found in the Firewood Creek deposit, the remains of Dinornis robustus are common throughout the South Island, Anomalopteryx didiformis is found widely in both the North and South Islands, whilst Euryapteryx gravis is widespread in the southern South Island (Oliver, 1974:580, 582 and 586).

The presence of three different species in the cleft (from a total of four moas) may be explained by the possibility that some time elapsed between the entrapments. Further radiocarbon dates on bone samples from the other moas found in the cleft may give a better indication of the passage of time between the first and last bird meeting it's demise. However, it is assumed from the tightly packed nature of the remains, that they were trapped in the cleft in relatively rapid succession.

Little empirical evidence is available to indicate whether moas foraged in species specific groups or if the various species mixed in free association. Accepting that the moas in the Firewood Creek cache met their end within a relatively short time span, it is plausible to infer that the various species often intermixed. Evidence of the existence of at least three different species of moas within small circumscribed areas of Central Otago is attested by the multiple species remains of butchered moas in the Hawksburn site (Hamel, 1978:119) and the Owens Ferry site in the Kawarau gorge (Ritchie and Harrison, 1981:99). It is unlikely that the meat of the different moas brought back to these Maori sites was obtained more than a few kilometres from the base camp, thus the different species must have been living in close proximity.

The Station deposit

The first indications of this deposit were observed in February 1981 by Mr Ivan McIntyre, a bulldozer operator working on the formation of the new Cromwell-Clyde highway alignment near the former Cromwell railway station (hence the name of the deposit). News of the discovery was relayed to the author by Mr T. Connor, the same Ministry of Works and Development overseer whose prompt actions had led to the investigation of the Firewood Creek deposit.

The station deposit was located at NZMS 1 map S133, grid reference 030687, a point 400 m north and about 100 m above the former station. The site consisted of a narrow infilled cleft within a massive schist formation which formerly constituted a spectacular rock face opposite Cromwell township (Plate 2).

The fill in the remnant cleft, after the upper rock had been stripped, consisted of a light brown loessic soil containing considerable quantities of fragmented schist, within which moa bones and the remains of other subfossil fauna were located. The deposit included several moas (all Anomalopteryx didiformis), two specimens of Cnemiornis calcitrans (the extinct South Island flightless goose), several other rare and extinct avifauna, tuatara and an unspecified lizard (refer to Appendix 3 for a detailed listing). Like the Firewood Creek deposit the remains are principally those of birds and animals which died either of starvation, or injuries sustained whilst falling into the cleft (Plate 3).

The excavation was carried out over two days with a crew of six (diverted from the S124/16 Parkburn ovens excavation which was in progress at the time). It was soon apparent that there were the remains of several moas within the cleft, and like the earlier find the bones were extremely intermixed. Every effort was made to bag bones and fragments belonging to individual specimens, but

this proved very difficult because of compaction within the deposit. The recovery of complete skeletons was also thwarted by the existence of a large damp area measuring about 50 cm in diameter on the eastern side of the cleft. In this part the bones were soft, fragile and generally proved non-recoverable; elsewhere they were sound No differentiation of the soil matrix surrounding the bones suggestive of gizzard contents was detected. Again the remains appear to have suffered lateral compression as a result of deformation of the cleft by earth movement subsequent to the deposition of the bones.

After two days of excavation, during which 70 cm depth of matrix was removed, the base of the cleft was exposed. The manually excavated portion of the cleft measured 2 m in length and 1.2 m in width. Like the Firewood Creek site, the cleft was orientated in a NW-SE direction in line with shear zones within the schist country rock.

Analysis of the Station deposit remains

The skeletal material from the Station deposit was speciated by Mr R.J. Scarlett (Plate 4). Compared with the Firewood Creek cache (which was located 1.5 km further north on the same rock face) it contained a much greater diversity of species, of which most are now rare or extinct in the Cromwell area (and the southern South Island).

The remains of at least six Anomalopteryx didiformis were found within the deposit based on mimimum number counts. There may, in fact, be the remains of as many as eight specimens based on small size range differences in the femora and tibiotarsi (Scarlett, pers. comm.). In addition the deposit contained six fragments of green moa eggshell and the remains of two specimens of each of the following species (refer Appendix 3 for details): the extinct South Island flightless goose and South Island weka, plus one specimen each of Finsch's duck, grey duck, laughing owl, little spotted kiwi, owlet - nightjar (Megaegotheles novaezealandiae), South Island robin, tui, South Island saddleback, paradise duck, New Zealand pigeon, tuatara and an unidentified lizard.

Like the Firewood Creek remains, all the bones in the Station deposit were tightly packed and mixed; seemingly the result of the various creatures falling or climbing into the steep sided cleft and becoming trapped over a short period of time. Lateral displacement and damage to the bones is partially attributed to the instability of the geological formations in this area (faulted schist overlain by a loessic mantle).

Dating the Station faunal deposit

Tibiotarsus fragments of Anomalopteryx didiformis were submitted for radiocarbon dating. This produced a date (NZ 5322) of-

Old T½	2530±60
New T½	2600±60
Secular corrected	2680±100 BP

Discussion

The radiocarbon date on the moa remains from the Station deposit predates that on the Firewood Creek remains by 1500 years. The evidence from these deposits is too limited to infer population changes through time, but is interesting that the Station cache contains the bones of only one moa species. Again, the concentration of the bones within the deposit suggests that the birds' demise occurred in relatively rapid chronological succession. Possible explanations include:

1. the moas were foraging in one group and fell more or less simultaneously into the cleft (the cache contained no juvenile remains),
2. the Anomalopteryx species was formerly prolific in the Cromwell area. Several individuals of the species fell into the cleft within a relatively short time span and were gradually buried by wind blown sediments and slope debris,
3. the calls of a trapped moa attracted others of its kind who in turn fell into the hole and became trapped.

The most plausible explanation to me is that small groups of Anomalopteryx were grazing or moving together around the slope and fell successively to their fate, possibly attracted by calls from the first trapped birds.

Six fragments of green moa eggshell were found intermixed amongst the faunal material within the cleft. These fragments have been identified, on the basis of their colour, as that of Megalapteryx by R.J. Scarlett. Obviously, there is a point of variance between the identifications of the moa skeletal material and the eggshell, however, a substantive discussion of the subject of moa species and the colour of their eggs is beyond the scope of this paper. It will suffice to say that the former existence of Magalapteryx didinus is well documented from many areas of Central Otago (Oliver, 1974:583), including the recovery of a most notable dried head near Cromwell (Oliver, 1949:9). Simpson (1955:254) and Oliver (1949:46) discuss the relationship between green moa eggshell and Megalapteryx remains.

Evidence of environmental and faunal changes: discussion and conclusions

An examination of the habitat preferences of the species present in the two sub-fossil deposits clearly illustrates that significant changes have occurred in the vegetation cover in the upper Clutha basin in the last 2500 years. Extensive forest cover has declined in the face of expanding areas of open grassland with scattered bush and isolated pockets of forest. These processes have probably accelerated following the entry of Polynesian man into the interior of the South Island.

Five of the species in the Station deposit are recognised forest dwellers: little spotted kiwi, tui, saddleback, robin and the pigeon. The presence of the remains of these birds in the deposit attests to the existence of dense forest, probably podocarp, in the immediate vicinity of Cromwell. Further support for this hypothesis is provided by the presence of dated totara logs in the nearby Pisa Range (Molloy et al, 1963). The presence of the South Island weka, probably also reflects the existence of forested stands in the tributary gullies flanking the Clutha valley, if not in the main valley (the weka, however, also frequents scrubland and the margins of lakes, swamps and the seashore). The weka, incidentally, persisted in the Cromwell area until the early 20th century. It was inadvertently killed off by poisonous baits laid for rabbits (Ritchie, 1980:45).

The presence of the remains of three types of ducks (Finsch's, the grey and paradise ducks) in the cleft, is difficult to explain as a natural phenomena. With the exception of the last mentioned, the ducks were represented by several bones. The presence of the duck remains indicates there must have been areas of the valley and river flats which were open or lightly vegetated.

The remains of one laughing owl were found in the cleft. This bird was formerly plentiful in Nelson, Canterbury and Otago, but may now be extinct. Recent reports are from Marlborough, Canterbury and near Lakes Te Anau and Wanaka (Oliver, 1974:436). The laughing owl was, as far as is known, more a bird of the open country rather than the forest. Sub-fossil specimens have been uncovered in Earnscleugh cave near Clyde. Its preferred nesting location was in rocky crevices and clefts; possibly the specimen uncovered in the Station cleft was nesting there.

The remains of a single owlet-nightjar (Scarlett, 1968:253) were recovered from the Station cleft. This small owl-like bird, closely related to a bird still found widely throughout Australia, is only known from sub-fossil remains in New Zealand (including Earnscleugh cave locally). It was probably extinct before the arrival of man (Scarlett, 1968:265).

The specific niche of the Anomalopteryx didiformis moa species is poorly understood, but its widespread distribution throughout both the North and South Islands and its presence in Maori sites in widely different environments, e.g. Shag River, Papatowai, Hawksburn and Owens Ferry, suggests it was an adaptable bird which could survive in both open and forested habitats. Hartree (quoted in Falla, 1962) was able to recognise the remains of solitary nests of Anomatopteryx on ledges and shallow cavities in limestone country in Hawkes Bay. This area formerly carried heavy forest.

The many crevices and rock overhangs in the Cromwell gorge (and areas of similar terrain in Central Otago) may have served as 'moa nesting foci'. Fragments of moa eggshell (green and white) were found in 60% (20) of the rock shelters test pitted in the Cromwell gorge during a testing programme undertaken in 1979 as part of the Clutha Valley archaeological project. Recognition of favoured nesting areas may have led to planned seasonal exploitation of the resource (i.e. hunting, egg gathering or both) during the human era. Such pressures on the nesting areas were probably greater than they could sustain, leading to declining moa populations.

Again, little is known about the ecological niche of the extinct goose of which the remains of two specimens were uncovered in the Station deposit. Bones of the bird have been found at a number of locations in Canterbury, as well as in Earnscleugh cave, Hamilton swamp and Dunstan in Central Otago (Oliver, 1974:602). Although its habitat preferences can only be deduced by analogy with related exotic birds such as the Cape Barren goose of Australia, presumably its bulkiness and inability to fly made it unfortunately suited to entrapment in steep sided clefts.

The skeletal remains of a tuatara found in the cleft is probably indicative of nearby forest cover. Tuataras prefer a friable, fertile soil and a bush canopy with abundent insect life (Hazeley: pers. comm.). The former existence of tuataras in Central Otago is also attested by the recovery of tuatara bones in the Rockfall 1 site (S133/121) in the Cromwell gorge. This site is radiocarbon dated to ca 1500 A.D.

The small fauna associated with the Firewood Creek deposit was very limited in comparison with that from the Station cache. Three species have been identified on the basis of single bones, the robin and two parakeet species, both are predominantly forest dwellers. In addition the mandible of a lizard of unidentified species was recovered.

Analysis and extrapolation from the habitat preferences of the species found in the two deposits supports earlier assertions e.g. Molloy et al (1963) that considerable areas of forest cover existed during the Holocene in the immediate vicinity of the present township of Cromwell. Over the past 2,500 years the forest cover has retreated. Causal explanations of this phenomena have been promulgated in a number of scientific papers by Cumberland (1962), Molloy et al (1963) and others.

Hamel (1978:120) has inferred from the degree of moa speciation, the plant species identified in recovered moa gizzards and the generally forested nature of the Tertiary landscape in New Zealand (i.e. during the period of moa evolution) that they were adapted to a wide variety of forest niches and that the native grassland areas in New Zealand did not or could not support moa populations in the absence of forests.

Molloy et al (1963) postulated that grassland habitats were uncommon even in the drier areas of Central Otago and Canterbury until at least 1000 years ago. The rapid and relatively sudden retraction of the forest after that date, for whatever reasons, must have severely depleted moa habitats and contributed to their extinction. The existence, some 2,500 years ago, of some unforested, probably open grassland with scattered scrub on the river flats in the vicinity of the junction of the Clutha and Kawarau rivers is also evidenced by the presence of the three duck species in the Station deposit, as well as the remains of rare and/or extinct birds such as the laughing owl and the owlet-nightjar which are believed to have preferred open habitats.

A recent study of gizzard contents (Burrows et al, 1981) confirms beyond doubt that members of the genus Dinornis (present in the Firewood Creek deposit) were browsing animals which inhabited forest or forest margins. Greenwood and Atkinson (1977) and Hamel (1979:63) have also presented plausible arguments for moa browsing of shrubs and the lower branches of forest trees. Burrows et al (1981) also infer that there would have been some niche differentiation based on the height differences between the various moa species and that the recognizable differences in the bill shapes of the various species reflects the exploitation of different niches.

To conclude, analysis of the sub-fossil fauna deposits uncovered during earthworks on the Clutha power project has provided useful information on the former existence of various species in the Cromwell area, besides substantiating inferences on climatic and vegetation changes during the Holocene. There is a reasonable likelihood that further deposits will be exposed

as earthworks proceed; they in turn will furnish new data towards answering the research queries addressed in this paper. In addition, the dating of moa bones found within the deposits has produced useful geomorphological information indicating the rate and recency of slip activity. This data can be applied during construction planning.

Acknowledgements

Special thanks to Mr Trevor Connor, Ministry of Works and Development, Alexandra. His prompt action in reporting the discovery of moa bones encountered during road construction enabled the deposits to be recovered and analysed. Thanks also to Mr Ivan McIntye whose keen eyesight first detected the exposed bones.

I am indebted to the following persons/institutions for assistance with the analysis of the excavated materials - Mr John Darby, Assistant Director, Otago Museum (Firewood Creek speciations), Mr Ron Scarlett, then Osteologist, Canterbury Museum (Firewood Creek and Station speciations), Dr Colin Burrows, Botany Dept., University of Canterbury (botanical identifications) and the Institute of Nuclear Sciences Radiocarbon Dating Laboratory.

My thanks to Annie Ross for assistance with the recovery of the Firewood Creek deposit, and to Sheridan Easdale, Karl Gillies, Anna Harrison, Chris Jacomb, Dilys Johns, Scott Mataga and Moira White for assistance in the excavation of the Station deposit.

Finally, I would also like to acknowledge the material assistance of the Ministry of Works and Development through the Project Engineer, Cromwell, and the N.Z. Historic Places Trust, Wellington.

APPENDIX 1.

Localities of reported sub-fossil deposits in Central Otago.

Author	Date	Locality
Murison	1871	Maniototo County
Fraser	1872	Earnscleugh Cave
Hector	1871	Cromwell, Earnscleugh Cave, Alexandra-Roxburgh
	1873	Earnscleugh area
Hutton	1874	Earnscleugh Cave
Booth	1874	Hamiltons, Maniototo
Chapman	1884	Mackenzie County, also Southland deposits
White	1895	Queenstown district
Gilkison	1931	Ettrick
Oliver	1949	Cromwell, Queenstown, Earncleugh Cave

Simpson	1955	Chatto Creek
Trotter	1970	Scaifes Lagoon, Wanaka
Beck & Ritchie	1980	Dart Valley, Rees Valley
Paterson	1980	Hamiltons, Maniototo
Burrows et al	1981	Scaifes Lagoon, Wanaka
Butement	diary	Glenorchy

APPENDIX 2.

Firewood Creek deposit: faunal identifications.

Moa speciations by Mr J. Darby. Moa speciations confirmed and small avifauna identified by Mr R.J. Scarlett.

Euryapteryx gravis: vertebrae?, 3 tibiotarsi, 1 femur, 1 pair tarsometatarsi.
Anomalopteryx didiformis: vertebrae?, tracheal rings, mandible, 1 femur, 1 tibiotarsus, 1 tarsometatarsus.
Dinornis robustus: 1 femur fragment, 1 tibiotarsus fragment, 1 mandible (incomplete), 1 maxilla (incomplete), 1 cranium (incomplete), 2 quadrates, 5 vertebrae.

Petroica a. australis (South Island robin): L. tarso-metatarsus
Cyanoramphus sp. (parrakeet): mandible
Lizard: fragment of mandible
Immature, not identified: tibiotarsus

APPENDIX 3.

Identified remains from the Station deposit, Cromwell.

Identified by Mr R.J. Scarlett.

Anomalopteryx didiformis (minimum number = 6)

L. tarsometatarsus (prox.end)	2	Vertebrae	44
L. tarsometatarsus	1	Secaricoids	2
R. tibiotarsus (prox. end)	3	Tracheal rings	100+
R. tibiotarsus (distal end)	1	Phalanges	38
L. tibiotarsus	4	Claws	13
L. tibiotarsus (prox. end)	1	Unguate process	2
R. tibiotarsus	1	Sternal rib	2
R. femur	4	Premaxilla	1
L. femur	5	Crania	1
R. femur (distal end shaft)	1	L. Quadrate	2
L. femur (proximal end)	1	Ribs	12
R. fibula	4	Unidentified fragments	11
L. fibula	3	R. fibula (prox. end)	1
Pubex	2	Hyoid 'rud' of tongue	1
Atlas vertebra	1	Fibula (distal end frag.)	1
Axis vertebrae	2	R. qudrate	2
Synsacral & cordal vertebrae	8	Projection of L.hyoid	1

Moa eggshell fragments (green) 6 (Megalapteryx?)

Apteryx oweni (little spotted kiwi)	Sub-adult phalanx, immature thoracic vertebrae, proximal end & shaft of R. femur, articulating head of L. femur, immature L. tibiotarsus

Cnemiornis calcitrans (minimum number = 2) flightless goose.

Ungual phalanx (claw)	1	Tibiotarsus, L. shaft	2
R. femur	2	Rib (prox. end)	1
R. ulna	1	Rib (frag.)	1
L. ulna	1	Carpometacarpus (prox. end)	1
Phalanges	3	L. radius	1
R. humerus (distal end)	2	L. radius (prox. end & shaft)	1

Tadorna variegata (paradise duck)	Articulating head of L. femur
Anas superciliosa (grey duck)	Part clavicle (could be Finsch's duck), R. coracoid, P & D. ends of L. carpometacarpus, vertebra
Euryanas finschi (Finsch's duck)	L. quadrate, part rib, R. ulna, L. acetabular region of pelvis
Gallirallus australis (weka) (2)	L. tarsometatarsus, distal ends of L. femurs (2), proximal end of L. tibiotarsus
Hemiphaga n. novaeseelandiae (pigeon)	Distal end of L. ulna
Sceloglaux albifacies (laughing owl)	Distal frag. R. tarsometatarsus, distal end of R. tibiotarsus, distal end R. femur, phalanx, shaft frag. of L. tarsometatarsus, sternal rib
Megaegotheles novaezealandiae (owlet-nightjar)	L. tarsometatarsus, L. humerus, R. carpometacarpus
Petroica a. australis (robin)	Synsacrum of pelvis, R. scapula, R. tarsometatarsus
Prosthemadera n. novaeseelandiae (tui)	Prox. and distal ends of R. tibiotarsus
Philesturnus C. carunculatus (saddleback)	Prox. frag. of L. tarsometatarsus, distal end/part shaft of tarsometatarsus, distal end of L. tibiotarsus, L. femur, prox. shaft of L. tibiotarsus, prox. end of L. femur, L. coracoid, prox. end of R. scapula, part of R. ulna, distal end of R. ulna, distal end of L. tarsometatarsus

	lizard	L. femur, frag. unidentified
Sphenodon punctatus	tuatara	Prox. end of L. tibia, part of L. femur, R. humerus, prox. end of L. humerus

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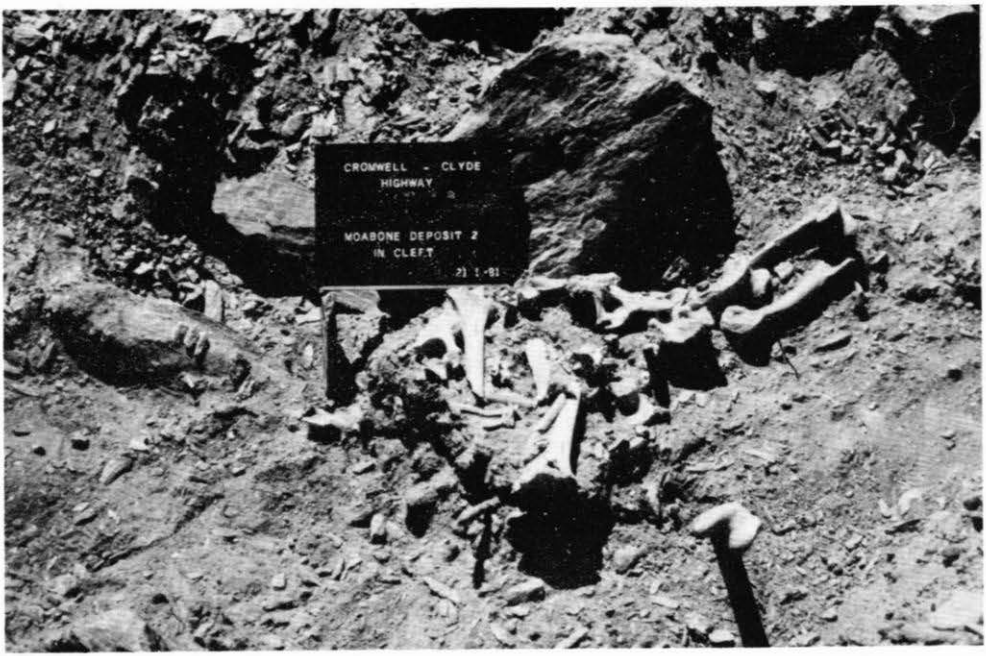
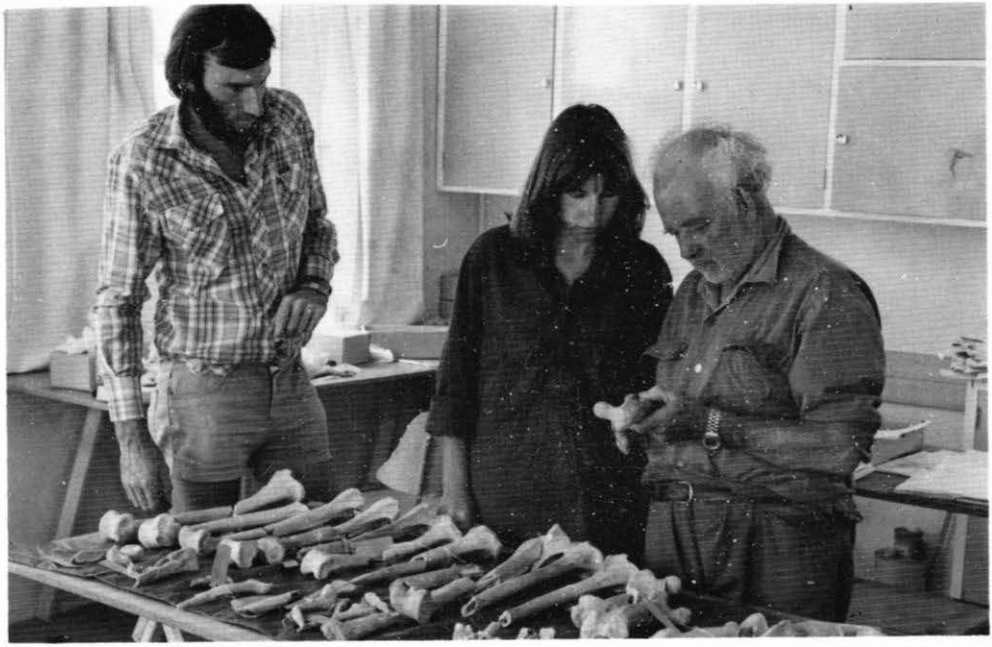
SUB-FOSSIL DEPOSITS Plate 1. Firewood Creek deposit during excavation.

SUB-FOSSIL DEPOSITS Plate 2. Excavation of Station deposit.



SUB-FOSSIL DEPOSITS Plate 3. Station deposit during excavation.



SUB-FOSSIL DEPOSITS Plate 4. Neville Ritchie, Anna Harrison and Ron Scarlett with moa bones in Cromwell lab.