POTENTIAL PRE-PLEISTOCENE FOSSIL TETRAPOD SITES IN NEW ZEALAND

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ABSTRACT

New Zealand lacks a satisfactory record of its pre-Pleistocene terrestrial vertebrates. However, the potential exists for their discovery because rocks of the right lithology and age to contain the required fossils are quite common. Favourable places to examine for fossil vertebrates include sedimentary interbeds in coal deposits, stream and lake deposits, tuff deposits, accumulations of freshwater and shallow-water marine molluscs, and fissure-fillings. Literature citations given for each of twenty-one sites listed indicate by example how the suitability of localities as potential fossil vertebrate sites may be determined.

INTRODUCTION

The modern terrestrial vertebrate fauna of New Zealand is quite distinct from that of the rest of the world, and reflects a period of extended isolation. Before the fragmentation of Gondwanaland in the medial and late Mesozoic, New Zealand tetrapods were probably quite similar to contemporaneous faunas in other regions of this supercontinent. If, however, New Zealand was then an archipelageic region, as Indonesia is now, the terrestrial vertebrate fauna may have had a strong endemic and(or) depauperate character even before the onset of separation. Whatever their previous nature, these connections between New Zealand and the remainder of Gondwanaland had been severed by the beginning of the Tertiary (Griffiths and Varne 1972). Then, if not before, the terrestrial vertebrate fauna began its separate evolution in response to the new climatic and biological conditions encountered by New Zealand as it drifted northwards.

These conjectures must be based largely upon the unique character of the modern fauna plus the final chapters of its history during the Pleistocene and Holocene, the recent and fossil floral evidence (Fleming 1962, 1963), and the history of the islands as deduced from geologic (Brown *et al.* 1968) and geophysical evidence (Griffiths and Varne 1972). Documentation of the actual history of the vertebrate fauna prior to the Pleistocene may be accomplished through the discovery of fossils in the Jurassic to Tertiary sediments known on both North and South Islands. Any new discoveries would not only give direct knowledge of the history of the New Zealand terrestrial vertebrate fauna but also provide information useful for unravelling the history of faunal interchange between various regions of Gondwanaland.

The search for fossil terrestrial vertebrates in sedimentary deposits in New Zealand is not necessarily hopeless, just because so few have yet been found. Little concerted effort has been made in the past, and if the vertebrate fossils present are the remains of small animals, as many well might be, they could easily have been overlooked in any examination where their recovery was not the specific objective. Outside of New Zealand, microvertebrate remains have been found in large numbers when underwater sieving has been attempted at sites where vertebrates were thought to be rare or absent (McKenna 1965).

Although New Zealand has only one known site where definite pre-Pleistocene tetrapods have been discovered (Timaru, Forbes 1891), it is geologically one of the best known areas in the world. Few other countries have been completely geologically mapped at a scale of 1 : 250 000, and many areas of New Zealand are mapped in greater detail than this. The information available permits a high degree of efficiency in the search for new fossil sites. Evaluating this large quantity of information for potential sites requires an understanding of the typical situations where fossil bones have been found elsewhere in the world. Familiarity with the numerous modes of preservation encountered can be gained by delving into the vertebrate palaeontological literature, the best guides to which are Romer (1966), Gregory *et al.* (1973), and Kummel and Raup (1965).

CRITERIA FOR LOCATING NEW SITES

Careful study of the characteristics of fossil terrestrial vertebrate sites reveals that there are in New Zealand a number of geological situations similar enough to productive overseas fossil sites to warrant investigation. The numerous coal deposits should be particularly promising. Elsewhere, vertebrate fossils are known to occur in close association with coal deposits, for example Bear Creek, Montana, U.S.A. (Simpson 1928), Husin coal field, Manchuria (Shikama 1947). Generally, the bones occur not in the coal itself but in shale, siltstone or sandstone interbeds. Fossils were frequently buried immediately above the coal; consequently bone is sometimes seen in the roof of a coal mine if the seam is removed right up to the overlying sandstone or shale.

Other potential fossil sites frequently encountered in New Zealand are stream channel and lake deposits. The classic "fossil fields" of the world, where one may walk for days over fossiliferous country rich in terrestrial vertebrates, demonstrate this mode of accumulation. In such deposits, one of the best places to look is at the bases of former channels as bones are frequently concentrated here. Sites of old channels can often be distinguished by the lenticular shape of the sediments that filled them. In addition, channel deposits are often noticeably coarser in texture than the surrounding overbank sediments. These are not hard and fast rules but useful field criteria to aid in selecting the areas to be most intensively examined. For a detailed study of the mode of accumulation of bones in a channel deposit, see Voorhies (1969).

Accumulations of wind and water-borne volcanic ash or tuff may yield rich concentrations of fossil bone. When tuffs form obvious channel-fillings and have not been deeply weathered, they are particularly promising deposits to investigate.

Fleming (1963: 93) pointed out that most New Zealand non-marine deposits are acidic, and therefore the chances of bones of terrestrial vertebrates and, for example, shells being preserved are generally quite low. For this reason, where shells are preserved, one at least knows that the chemical conditions are not a factor working against the prospect of recovering bone. Rich concentrations of pre-Pleistocene freshwater molluscs with the original calcium carbonate shell preserved are unknown in New Zealand. Such deposits, were they present, would be ideal prospects. However, the frequently encountered brackish water and shallow water marine deposits rich in shell material can yield bones of terrestrial vertebrates. A possible New Zealand example of such a situation is a locality in the Lower Waipara Gorge where terrestrial vertebrates have been collected in association with shallow water marine molluscs (Rich *et al.* MS).

Caves and sinkholes in limestone may serve as traps or dens for animals and as sites of accumulation of their bones. Unfortunately, modern, open caves rarely have pre-Pleistocene deposits in them, so one must investigate completely filled-in ancient caves. Fissure-fillings represent such former caves, and are frequently seen in commercial limestone quarries. Because the fissure-fillings tend to break down faster than the surrounding limestone it is quite difficult to detect these deposits on a natural outcrop. Although I have not come across a description of a fissure-filling, either in the literature or in conversation with local geologists, the widespread occurrence of limestone deposits in New Zealand makes this an avenue that should be investigated further.

A final mode of accumulation of fossil bones is in the hollows of tree stumps. At the Joggins locality in Canada, trees were apparently buried in mud while still upright. The trees died and the part buried in mud became a natural pitfall trap once the remainder of the tree above ground fell over and the inner parts of the plant rotted away (Carroll *et al.* 1972).

POTENTIAL SITES

The twenty-one potential fossil sites listed below were selected from only three New Zealand serials, on the basis of their similarity to productive terrestrial vertebrate fossil sites described in overseas studies. These papers should be sufficient to indicate the most promosing kinds of situations for investigation. No attempt has been made to keep up to date with the latest stratigraphic terminology applied to the units discussed. Generally, the names used by the authors cited have been employed here. For the reader interested in checking on more recent useage, Fleming (1959) is a useful

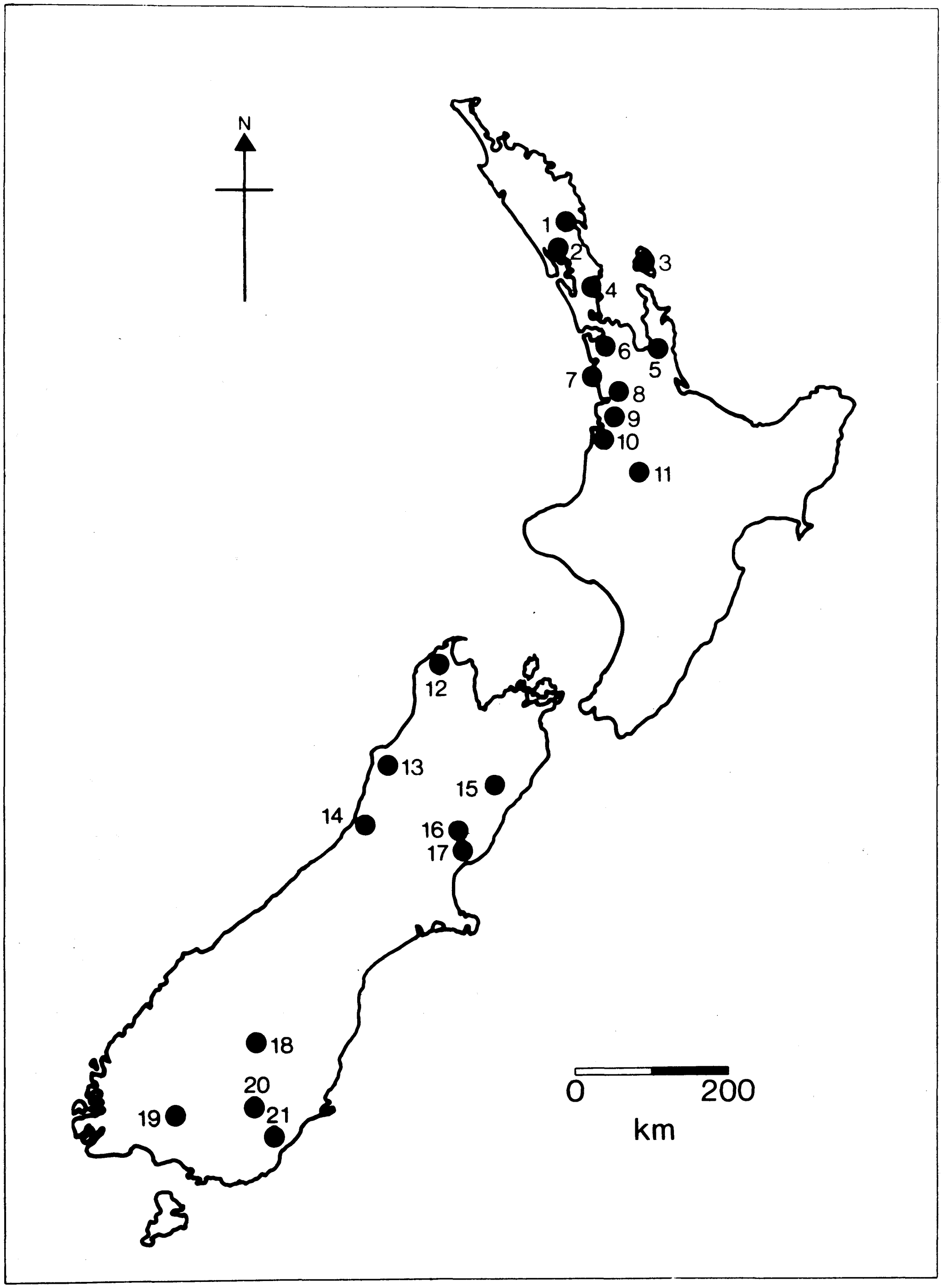

Fig. 1. Index map showing general location of potential fossil localities mentioned in text.

starting point, as are the maps of the New Zealand Geological Survey for the area in question. When searching for potential sites, the older geological literature dealing with an area should not be ignored just because a more modern treatment exists. Frequently, older works contain information useful in the present context that would not be included in a more recent paper.

1. Waipu - Maungakaramea. Purna Beds (Miocene in part): non-marine beds above Miocene marine deposits. Includes tuffaceous sandstone with lignites, lacustrine deposits, and reworked tuffs. Ferrar (1934).

2. Tinopai. Puketi Formation (Miocene): cyclic succession of andesitic to pumiceous beds with soil horizons and lignite seams forming top of each cycle. Jones (1969).

3. Barrier Island. Beesons Island Volcanics (Miocene). Impressions of *Hyridella* in siltstone within tuffaceous sediments that alternate with breccias and lava flows. Hayward (1973).

4. Warkworth - Mangawai Estuary - Kaipera Flats. "Auckland Coal Measures" [= Kamo Coal Measures] (Eocene). Ferrar (1934).

5. Table Mountain. Whitianga Group and Beesons Island Volcanics (Neogene): impressions of *Hyridella* in tuffaceous sedimentary interbeds between lava flows. Bell and Fraser (1912), Fraser (1910), Hayward (1973), Henderson and Bartrum (1913).

6. Port Waikato. Huriwai Formation (Jurassic): terrestrial, coarse sandstone, conglomerates, and breccias with thin coal lenses and abundant plant remains; small lamellibranchs, probably non-marine found at N51/296946. Purser (1961).

7. Waikato River - Kaawa Stream. Landon (Oligocene): good coastal exposures of marine and non-marine deposits between Waikato River and Kaawa Stream. Immediately to the south of Kaawa Stream are stream-bedded sands that contain lignites and immediately overlie marine units. Gilbert (1921).

8. Waikato Basin. Waikato Coal Measures (Eocene): in the basin of the Waikato River, the most terrestrial conditions of deposition were in the Huntly-Glenafton area. Henderson and Grange (1926).

9. Whatawhata. Mangakotuku Siltstone (Oligocene): a prominent shell band in this unit is apparently estuarine. Shell band is widely distributed in district, forms prominent outcrops, and is bracketed by coal seams. Laird (1967).

10. Te Maika. Upper Jurassic Beds: fossil stumps preserved in the position which they grew. Uncertain from text whether fossils are casts or not. If casts, stumps may have acted as pitfall traps. Henderson and Grange (1926).

11. Te Kuiti. Whaingaroa Series (Oligocene): estuarine sandstone, clays and coals developed in basal 50 feet

of unit. Marwick (1946).

12. Whanganui Inlet - Kahurangi Point. Coal Measures (Cretaceous - Eocene): brown coal. Low sulphur content of coal indicative of accumulation of plant debris in non-marine conditions. Unit outcrops at base of inland facing cliff that parallels coast. Outcrop area clearly delimited on New Zealand Geological maps S1-3, 1:63,360 (Bishop 1968, 1971). Ongley and Macpherson (1923).

13. Reefton. Quartzose Coal Measures (Eocene): several occurrences of *Hyridella* in this unit. Henderson (1917), Morgan and Bartram (1915), Suggate (1957).

14. Greymouth. Ford Formation (Cretaceous): regarded as lacustrine deposit. Enigmatic objects resembling modern land snail *Paryphanta* commonly occur in this unit. One specimen of *Hyridella* also known.

    Waiomo Formation (Cretaceous): regarded as lacustrine deposit.

    Rewanui Formation (Cretaceous): cast of log composed of sandstone and surrounded by coal personally observed at S44/801957 in a cut on the south side of the Rewanui railway. The log was lying parallel to the plane of bedding and thus could not have acted as a pitfall trap, but presence indicates that further searching in Rewanui Formation might yield upright casts of stumps. Gage (1952).

15. Quail Flat. Gridiron Formation (Cretaceous): basalts with sedimentary interbeds. Plants and invertebrates (non-marine?) found by McKay in 1885 but none collected since. McKay (1886), Suggate (1958), Thomson (1920).

16. Waipara River. Haumurian Series (Cretaceous): contain *Ostrea* coquinas at the base of unit immediately above the Mata Series Coal Measures. These coquinas are present at Doctor's Gorge, Boby's Creek, Birch Hollow and Weka Creek. Short faunal list for coquina plus locally overlying coal deposits suggests possibility of terrestrial influence although all forms listed are marine. Harrison (1907), Thomson (1920), Wilson (1963).

17. Lower Gorge of Waipara River. Double Corner Shell-beds (Miocene): have yielded a small terrestrial vertebrate fauna from a lens possibly conformable within a coquina layer. Lens distinguished lithologically from surrounding marine unit solely by presence of coarse greywacke granules, apparently derived from the Torlesse Group, and bones of terrestrial vertebrates, for example *Sphenodon punctatus*. In gross appearance, the lens is a sandy coquina not markedly different from the surrounding rock. Gregg (1959), Rich *et al.* (MS), Wilson (1963).

18. Alexandra. St. Bathans Beds [= Central Otago Lignites, Wedderburn Formation, Manuherika Formation] (Miocene): freshwater molluscs and fish frequently found. Excellent area for intensive search because the lithic unit is widely exposed and readily accessible. Ferrar (1929), Park (1906, 1908).

19. Ohai. Ohai Group (Cretaceous): quartzo-feldspathic sandstones and mudstones, conglomerates, and coal seams.

Beaumont Coal Measures (Eocene): quartzo-feldspathic sandstones and mudstones, coal seams; *Hyridella* occurs in nodules.

Three weeks spent by me examining Opencast Nos. 3 and 6 immediately northwest and north of Ohai during March and April, 1974, failed to yield a single bone fragment although remains of *Hyridella*, a freshwater mussel, were quite common in the Beaumont Coal Measures. Bowen (1964), Mutch (1972).

20. Gore. Pomahaka estuarine bed (Oligocene): slabs of this material were collected as early as 1861. Several molluscan taxa are known, a mixture of marine and non-marine forms. Only one outcrop was visible during the period of Wood's investigation, 1945-1950; a recently excavated creek at S170/065541. Original outcrop probably at S170/068540 on Pomahaka River; site now overgrown but river action could cause new exposures. Unit is mapped at one other area but exposures not seen during 1945-1950 period: S170/080578. Wood (1956).

21. Kaitangata. Taratu Formation (Cretaceous): unit alternates between gravel and conglomerate layers and coal horizons that include sandstone, shale, and mudstone interbeds. Mudstones commonly form roofs of mines. Coal horizons form poor outcrops. To investigate, either get down in mines to examine fresh roof surfaces if this is possible, or look at tip heaps. Although no macrofossils have been reported from this unit, low sulphur content suggests non-marine conditions of deposition. Harrington (1958), Ongley (1939).

AFTERWORD

Once a fossil site is discovered, the work is not over if the find is to be of scientific value. The site must be excavated in such a manner that the geological age and geographic location of the specimens are documented carefully and accurately. Then the specimens must be identified, described, illustrated, and their significance interpreted. A careful, thorough approach is necessary, or the scientific importance of the discovery may be minimal. In these situations it is perhaps best to secure advice from professional palaeontologists on the staffs of major institutions. It is better to leave as much undisturbed material in the ground as possible until a professionally trained person can examine a site. Much valuable information about fossils is derived from knowing their relationships with the surrounding rock. Once this is lost, it is lost forever.

POSTSCRIPT

Single dyeline copies of the original notes and map employed for compiling this report are available from the author at cost (presently $A4.00) to any who are interested.

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