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PAKOHE – A ROCK THAT SUSTAINED EARLY MAORI SOCIETY IN NEW ZEALAND

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Abstract. In the eastern ranges of Nelson, in the northeast of the South Island of New Zealand, Maori extensively worked a fine grained mudstone, "pakohe", into tools. In the Archaic Period, dating from when Maori arrived in New Zealand in the 12th or 13th century to about the end of the 15th century, pakohe was, after the much rarer pounamu or greenstone (nephrite), the preferred material for stone implements. Boulders of pakohe from the coast and in the rivers were worked into the required shape using marine rounded hammer stones of granodiorite. The source of the pakohe was traced inland to a distinctive belt of barren dun weathered outcrops dominated by serpentinite. Europeans who founded Nelson in 1841 named these rocks the Nelson Mineral Belt. Scientifically it is the Dun Mountain Ophiolite Belt, a slice of Permian oceanic crust and upper mantle. The pakohe occurs as rootless blocks up to c.10 m or more across, within melanges. The blocks protrude above the general level of the land and was broken into suitable sized pieces using boulders of granodiorite. Although pakohe is an extremely tough rock, due to the presence of albite and tremolite, it splits conchoidally thereby making it possible to work. As the Archaic Period gave way to the Classic Period of Maori culture the use of pakohe declined in favour of more locally sourced rocks throughout New Zealand. The reasons for this are obscure, but are probably linked to a cooling climate and the extinction by hunting of the giant flightless Moa, which all contributed to putting pressure on Maori society. It this appears that those working and distributing pakohe were displaced by tribes moving into the Nelson area in the competition for food and other resources. With the introduction of iron tools coupled with the advent of the inter-tribal musket wars in the early 19th century, the quarries were abandoned and by the time of the European settlement they were forgotten. They were rediscovered during the latter part of the 19th century but, except from local amateur naturalists and ethnologists, they initially gained no other recognition. The founding of the Polynesian Society in 1892 placed the study of ethnology on a more permanent footing although it was not until two decades later that the first descriptions of the quarries appeared by Henry Devenish Skinner (1886-1978) and James Allan Thomson (1881-1928) in 1910 and 1918 respectively.

1. INTRODUCTION

New Zealand is the most recently inhabited country in the world with the indigenous Maori arriving from the tropical and sub-tropical islands of the central Pacific in about the 12th or 13th centuries. Although New Zealand, comprising two main islands, is largely mountainous it has a temperate climate with plentiful food and rock resources. Fish and birds, including the large flightless Moa, were in abundance. While there were no land mammals, other than two species of bats, the coast abounded in seals and stranding of whales and dolphins also yielded food and bone. There were large areas of forest that provided wood for the construction of buildings

and canoes as well as for fuel. Flax and vines were utilised to make clothing, ropes and nets. Plants, particularly fern roots and berries, were also a source of food. As well as indigenous resources, the Maori brought with them to New Zealand a number of plants and animals, including the sweet potato or kumara, yams, dogs and rats. Although a tradition of pottery existed in the central Pacific, being brought by the ancestors of Maori from Asia several millennia earlier, it was never introduced in New Zealand where clay abounded.

While the first documented European visit to New Zealand was by Abel Janszoon Tasman (1603-1659) in 1642, it was not until the early 19th century that European tools fully supplanted Maori stone culture. A range of different rock types were utilised for making tools and to a lesser degree ornaments. These included pounamu or nephrite, a form of jade, and an altered or metasomatised mudstone known to the Maori as pakohe (Fig. 1) and to the early European settlers as "baked argillite". In addition there are a variety of hard sandstones and igneous rocks, particularly basalt, that are suitable for tool manufacture. Quartz in the form of rock crystal, quartzite and obsidian were broken into fragments with razor sharp edges that were used as knifes for cutting flesh and materials. Ochre and a few other minerals supplemented natural dyes for colouration of buildings and body ornamentation. In addition, in the central North Island geothermal steam and hot springs were utilised for cooking and heating. Other minerals and rock resources that New Zealand had an abundance of, such as alluvial gold, coal and, other than for ochre as a colouring medium, iron ore were never exploited by Maori.

Figure 1`. Examples of pakohe adzes (drawn adzes on the right from Challis 1978).

Although New Zealand, for its size, has a huge diversity and an abundance of hard rocks there were relatively few that had the necessary characteristics to be consistently made into tools. These characteristics were sufficient toughness so that they would not break during use, they were capable of being sharpened so as to maintain a cutting edge and critically they could be worked into a suitable shape. Of these, the greatest limiting

factor was workability bearing in mind that the Maori could only do so with rock. While set patterns for tools like adzes evolved, many were manufactured on an opportunistic basis when a piece of rock of suitable quality and shape was fortuitously found, such as loose material naturally spalled from an outcrop or found as float in rivers or on beaches. For example, hard sandstones are widespread in New Zealand but in outcrop they were almost impossible for the Maori to work. Nevertheless, sandstone boulders are abundant in many rivers and, due to winnowing during movement, softer boulders or those containing planes of weakness are eliminated. Such rivers had the potential of yielding pieces of rock of suitable quality and size that did not require a huge amount of preparatory work. Nevertheless, of all the rocks that were worked, the most in demand were pounamu and pakohe, both of which are associated with ultramafic rocks. Both pounamu and pakohe are hard and tough and could be highly polished. Of the two pounamu, was the more prized because of its beautiful green translucent colour and that it could be sawn and carved (Beck and Mason, 2002).

2. POUNAMU

While most tools made of pounamu were primarily adzes and chisels for fine carving, they tended to have more intrinsic values and were treated as treasures or taonga. This was particularly so for mere, a type of short club used in close combat fighting as well as a sign of rank or authority. Pendants included the elaborately carved hei tiki that was hung around the neck. To Maori these objects had their own mana which can be interpreted as authority, prestige or power, and were handed down from one generation to the next. They could be given as an act of friendship or their loss in battle exemplified defeat or submission.

Nephrite obtains its toughness from the presence of interlocking crystals of tremolite, a calcium-magnesium amphibole. Most of the high grade nephrite is derived from thin lenses of Pounamu Ultramafics within highly metamorphosed sedimentary rocks of Permian or early Mesozoic age exposed in the Southern Alps in the west of the South Island (Fig. 2). As far as is known these were not worked by the Maori and instead boulders were collected from the rivers draining the alps or from coastal beaches where gravel is constantly moved by longshore drift. These processes progressively reduced the boulders in size, making them more manageable as well as removing any softer layers such as serpentinite. Because the rivers are large and frequently flood, they shift huge volumes of gravel so that even though they were not common, there was no significant decline in the availability of suitable boulders for tools. Nephrite and semi-nephrite is also derived from the Dun Mountain Ophiolite Belt and its associated melanges that are exposed at either end of the South Island, in Nelson and Otago-Southland, on opposite sides of the Alpine Fault. However, the amount of nephrite or semi-nephrite eroded from the belt is small, particularly in Nelson. On the other hand pakohe within the northern melanges is relatively widespread.

3. PAKOHE

The most widely exploited rock in early Maori settlement, commonly referred to as the Archaic Period that ended at approximately the end of the 15th century, is pakohe. Although commonly referred to as argillite this term is unsuitable in that it is not greater induration that gives the rock its exceptional properties but chemical alteration arising from the formation of various minerals, mainly albite and tremolite. In particular, tremolite has imparted an interlocking felted fabric that replaces the platy fabric of the original mudstone thereby giving pakohe additional strength and toughness (Reed, 1959). While the qualification of baked or metasomatised

argillite reflects this alteration the term argillite remains unsatisfactory. Consequently, the Maori word of pakohe for rocks that are dominantly fine-grained and altered by the formation of albite and tremolite is adopted in this article.

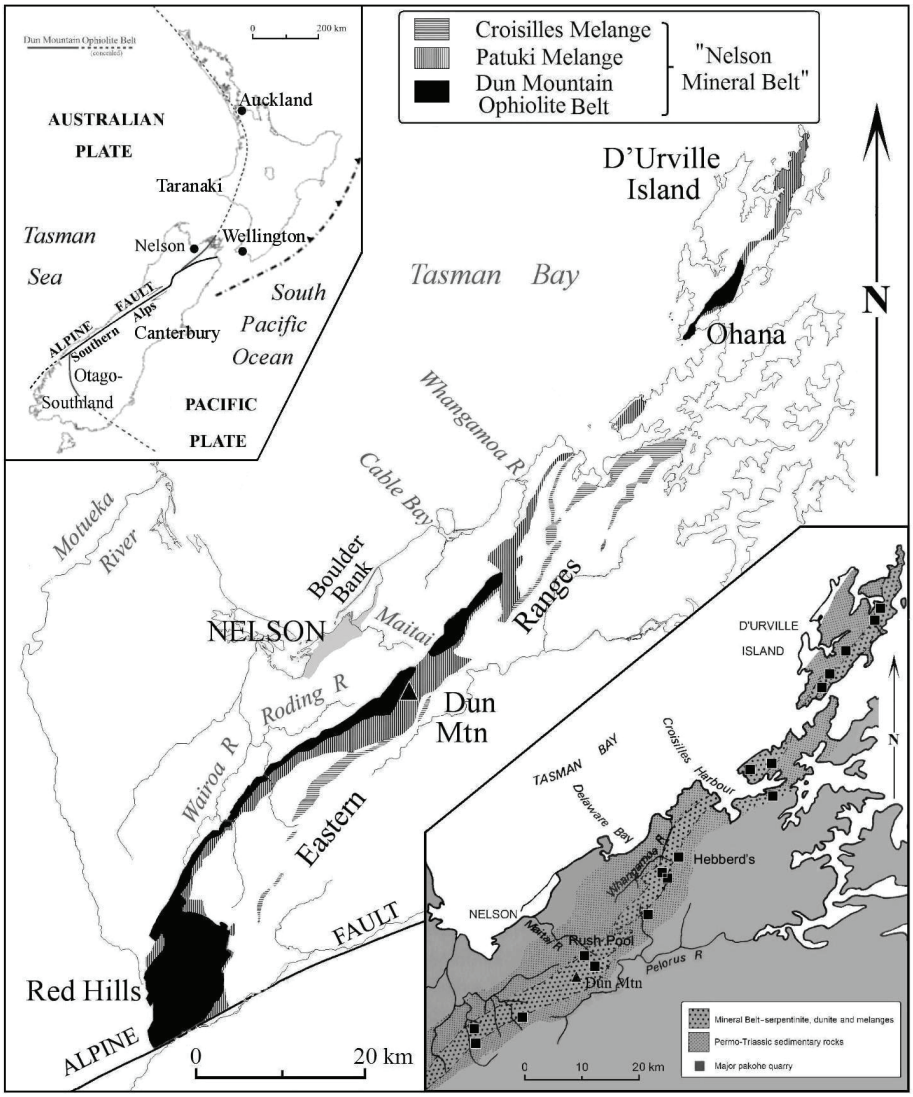

Figure 2. The Dun Mountain Ophiolite Belt and Patuki and Croisilles melanges ("Nelson Mineral Belt") in eastern Nelson modified from Rattenbury et al. (1998). The inset map top left shows the tectonic setting of New Zealand with the Dun Mountain Ophiolite Belt offset by the Alpine Fault; the inset map of the major pakohe quarries is modified from Walls 1974.

Pakohe is mostly found in the ranges of east Nelson, in the northeast of the South Island, and was exported throughout New Zealand. It occurs as blocks within the Patuki Melange on the southeastern side of the Dun Mountain Ophiolite Belt and in the very discontinuous Croisilles Melange that crops out up to 10 km farther east (Rattenbury et al., 1998; Fig. 2). The ophiolite represents a slab of Early Permian oceanic crust and underlying ultramafic rocks of the upper mantle, the latter dominated by serpentinite, that was emplaced into continental crust on the margin of Gondwanaland. Because traces of copper and chromite were found by European settlers in the ultramafic rocks in the late 1850s, they and their associated rocks were collectively referred to as the "Nelson Mineral Belt". Soils derived from the weathering of the ultramafics are rich in magnesium, which prevents the uptake of what little calcium is available, resulting in a stunted vegetation that at higher altitudes is dominated by shrubs and tussock among which protrude outcrops of rusty weathering outcrops. This vegetation contrasts markedly with the forest on more normal rocks that enclose the serpentinitic and related rocks. Mountains in the belt had bestowed on them names such as Red Hill, Red Hills and Dun Mountain by the European settlers. However, at lower altitudes denser vegetation tended to prevail.

When the ophiolite was emplaced, blocks of the adjoining country rock along with parts of the ophiolite, were fragmented and enclosed in a matrix dominated by sheared serpentinite resulting in the melanges. The blocks range in size from less than 1 m to over 1 km in length although most are no more than tens of metres across (Fig. 3). As they were incorporated into the melanges most of the blocks were tectonically rounded, particularly the smaller ones, and many have been altered by metasomatism with the formation of new minerals.

Figure 3. A partly worked in situ block of pakohe, c. 6 m in height, at the Rush Pool Quarry.

This is particularly evident in blocks of mudstone, which rarely exceed the size of a small cottage. The mudstone almost always has a consistent homogeneous texture and varies in colour from light to dark grey to black, although green, white and red streaks may be present. The streaks represent sparse thin sedimentary layers that have become distorted during metasomatism. Although lacking the translucent green beauty of pounamu, pakohe is capable of taking a very high polish, which with its toughness, is now making it increasingly in demand by carvers. Unlike pounamu, pakohe could not be sawed by Maori but as it has a well developed propensity to fracture conchoidally, this allowed it to be worked and shaped. As the ophiolite and its associated melanges are well developed in eastern Nelson from D'Urville Island southwards through Dun Mountain, it is no coincidence that the greatest number of sites for manufacturing adzes and other tools are found there (Walls, 1974).

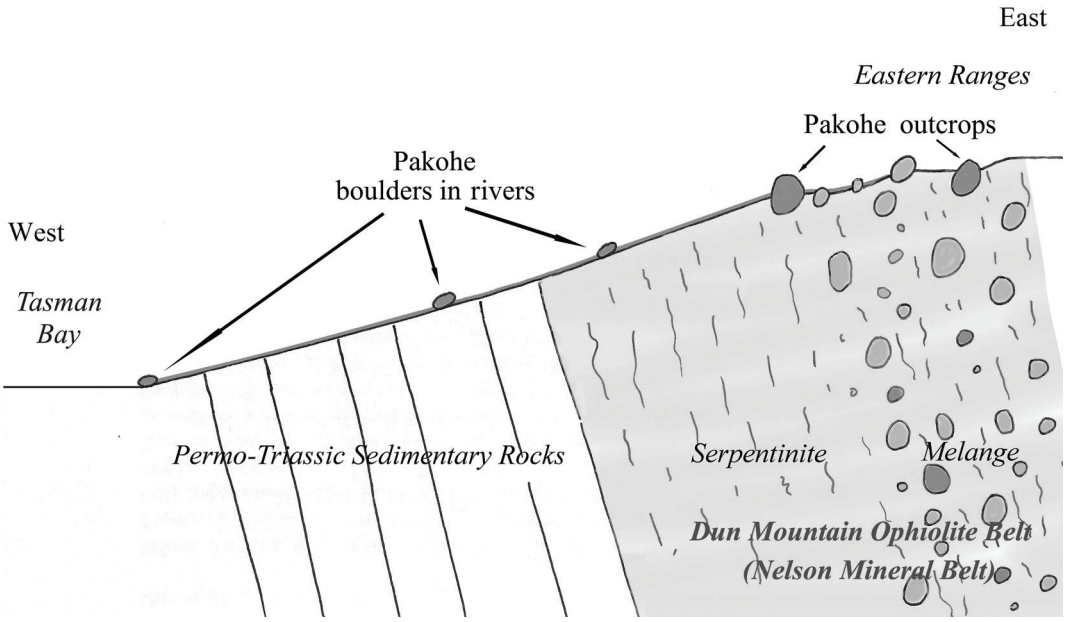

Figure 4. A diagrammatic section through eastern Nelson showing the source of the pakohe blocks.

4. ROCK TO ADZES

The first use of pakohe would have been from boulders eroded from the melanges on the coast, particularly at D'Urville Island, and in the rivers, such as the Whangamoa and Maitai, flowing west from the eastern ranges into Tasman Bay. Some of these boulders would have been complete small blocks eroded intact from the melanges. Where possible Maori would have hauled them onto land before breaking them down into more manageable pieces using large boulders. The preferred hammer stones were oval shaped granodiorite from a 13 km long Boulder Bank (Fig. 5) at the head of Tasman Bay and a much shorter bank or tombolo at nearby Cable Bay. The granodiorite is homogenous, with no preferred planes of weakness, and having been subject to

vigorous wave action, they make ideal hammer stones that are available in any required size. The pieces were then worked, using small handheld boulders, into preforms leaving behind a pile of conchoidal pakohe flakes as evidence of where a suitable boulder had been found. Although granodiorite was widely used, a variety of other suitable lithologies, including green sandstone and a hard calcium garnet-rich rodingite derived from the ophiolite belt, were also employed as hand held hammers (Skinner 1914). The preforms were then carried for completion to more congenial places, such as permanent villages. However, at camping spots on the way it was general practice to further shape the preforms, and it is common to find pakohe flakes in association with middens and other evidence of habitation. The preforms were further reduced by carefully removing smaller flakes and as the desired shape was approached final shaping was done by repeated delicate hammering at right angles to the face which "bruised" the surface. For adzes and other tools requiring a cutting edge or face, a final polish was obtained by grinding the adze against softer blocks or boulders of sandstone of varying grain size.

Figure 5. Nelson Boulder Bank separating Tasman Bay (left) from Nelson Haven. Granodiorite boulders forming the bank were a major source of the hammer stones used in the pakohe quarries. Note 1 m scale in inset photo.

In seeking the source of the boulders, Maori would soon have associated the pakohe with the distinctive rocks and vegetation of the "mineral belt". Because the vegetation is stunted and easily burnt it is highly probable that Maori used fire to clear the ground to aid prospecting. Certainly in summer the vegetation would have been easy to ignite and fires, either deliberately or accidentally lit, would have raced along the "mineral belt" at higher altitudes but would have made little inroads into the denser, and wetter, forest enclosing it. This

practice was later employed by the European prospectors searching for copper and chromium ores. Maori was also fortunate that pakohe did not occur in a regular manner, such as in a layer or lode that would have proved difficult to work. Instead, because the soft serpentinitic matrix of the melanges is relatively easily eroded, the enclosed blocks, including those of pakohe, stand out above the surrounding country side.

Once a suitable pakohe block was found, then large granodiorite boulders were manhandled to the site. With the largest boulders found in a quarry weighing over 25 kg this was no easy task. As the blocks commonly have a whitish weathering rind, which was generally too soft to be suitable for tools, and was removed by pounding it with hammer stones to expose the fresh rock. By then directing the hammer stones at identified points, such as corners or where there were fortuitous natural fractures, pieces of suitable rock were spalled from the block. Although the first descriptions of the quarries envisaged that the face of a block was heated by an intense fire being lit against it and then rapidly cooled by quenching with water, there is no evidence for this (Duff, 1946). It was apparently not appreciated by the describers that the rock could be spalled by carefully directed repeated hammer blows. Once pieces of pakohe of the required quality had been obtained these were shaped into preforms using smaller handheld cobbles and boulders. Like the preforms obtained from boulders in the rivers, they were taken to more convenient sites for their final shaping. It is unlikely that all of the pakohe outcrops were found in a relatively short space of time and that ease of access may well have been a contributing factor as to when they were worked. It is clear that in some quarries it was becoming increasingly difficult to extract suitable rock. Despite this at a number of readily accessible quarries apparently suitable, and extractable, rock remains. This implies that prospecting and ultimately quarrying inland was not simply initiated due to exhaustion of the more accessible pakohe, whether it was in boulder or outcrop form. Thus it is probable that by tracing boulders of pakohe up the Maitai and other rivers from the settlements at their mouths, some outcrops were found early in Maori settlement of the area.

5. DECLINE OF PAKOHE

As pakohe use declined in favour of more local rocks elsewhere in New Zealand there was also a change in adze style although this is by no means straightforward (Leach, 1990). Generally the earlier adzes have a square to quadrangular cross section but became more rounded with a broader blade relative to their length, as the Archaic Period gave way to the Classic Period (Challis, 1978: 74). Why the use of pakohe tools declined from around the end of the 15th century, with a corresponding increase in a wider variety of other types of rock from throughout New Zealand, has been the focus of much discussion. This decline in pakohe is clearly shown in numerous archaeological sites in New Zealand, including on D'Urville Island where Wellman (1962) recognised two occupation layers. The oldest layer contains abundant pakohe tools and fragments, moa and fish bones and, so Wellman postulated, there was kumara cultivation. He calculated that the volume of pakohe fragments on the island indicate at least 15,000 adzes were manufactured. Although he acknowledges that this is a crude estimate, it nevertheless, graphically shows the importance of pakohe for those living on the island and its usage generally in early Maori society. The age settlement commenced on the island is not clear but could have been as early as 1100 to 1200 AD and was definitely well established by 13th century (Challis, 1991). The younger layer, dating from around 1500 AD, is characterised by only sparse fragments of pakohe, an absence of moa remains and that fish formed a high proportion of the occupants' diet. The apparently irrefutable inference is that there was a dramatic change in the circumstances of Maori who were working and trading pakohe.

Certainly, at about this time a number of factors were influencing indigenous society and included the transition to a cooler climate from what in the northern hemisphere is commonly referred to as the "Medieval

Warm Period", the peak of which coincided with the arrival of Maori in New Zealand. The following "Little Ice Age" would have been detrimental to the growing of kumara by Maori although the effects of this cooling would have become more noticeable in the southern districts of New Zealand. Even more devastating was the hunting of the moa to extinction thereby putting further pressure on food availability. With diminishing food resources, competition between the large number of tribal groups or iwi within New Zealand would also have increased putting further strain on Maori society. These factors, at the very least, would have made living more difficult but in the coastal settlements of eastern Nelson fish and shellfish abounded and kumara growing was still possible so a lack of food is not a likely reason for the cessation of quarrying. Perhaps of more significance is that the distribution network for preforms and finished tools was interrupted and this could have forced a reliance on local materials elsewhere in New Zealand. Nevertheless, such an interruption would have to be of such magnitude that it resulted in the virtual collapse of the trade in pakohe.

Another factor was whether the pakohe resource was becoming exhausted. At first glance this does not appear to be so for pakohe is still found extensively as boulders in the rivers and in outcrops in the eastern ranges. However, this is a little misleading as on the coast, and particularly in the rivers, the easily recoverable boulders would have been removed and replenishment by sea and riverbank erosion would have been very slow. For example, very large floods would have been necessary to turn over the riverbed and in particular erode gravel banks thereby releasing pakohe boulders. In the outcrops it would have become increasingly difficult with the primitive tools available, and despite the undoubted skill of the Maori craftsmen, to extract the rock once natural weaknesses such as corners and fractures had been taken advantage of. Furthermore, many outcrops, particularly those deficient in tremolite, were of inferior quality and mostly unsuitable for tool manufacture. All of these factors could have made alternative sources throughout New Zealand more attractive leading to a diminishing in importance of pakohe, despite its overall superiority. Nevertheless, the resource available to Maori was not exhausted, even if it was becoming more difficult to obtain the volumes of rock quarried in earlier years. There were also probably significant volumes of rock that had previously been rejected that would have still have been suitable. These factors would have only resulted in a gradual change in the proportions of the various rock types used to make tools, namely a decreasing proportion of pakohe and increasing use of other rocks including pounamu. Instead the decline in pakohe use appears to be much more abrupt, suggesting a more calamitous cause

Support for a dramatic decrease in the use of pakohe is shown in a major quarry at Ohana on the south-eastern coast of D'Urville, the working of which Wellman (1962) correlates with his early occupation layer. While a large amount of rock has been quarried, as exemplified by an extensive area of pakohe flakes, blocks of apparently suitable rock still remain. Thus the inference is that the cessation of quarrying was not due to a lack of suitable raw material. Instead the simplest explanation is that quarrying was brought to a halt by external factors that for those in eastern Nelson were catastrophic. This could have arisen from an invasion of eastern Nelson by hostile tribes. Certainly migrations from the north, with the generally far from peaceful displacement or subjugation of the local inhabitants, are a recurring theme in Maori history. Around 1500 AD one such migration may have been so devastating that working of pakohe almost ceased although some tools were still manufactured from already quarried rock or natural boulders. The shortfall in pakohe was made good by using other rock types from throughout New Zealand. With the introduction of European tools, particularly from in the early 19th century, the Maori quarrying and working of stone collapsed entirely. Documented invasions of eastern Nelson by North Island tribes continued into the 19th century with the last such event being in the late 1820s and involving muskets. By the time of organised European settlement of Nelson the working of pakohe was all but forgotten.

6. RECOGNITION OF THE QUARRIES

Although Europeans settled in Nelson in significant numbers from the early 1840s, it was a long time before the pakohe quarries were recognised. In the first decade of European settlement a number of surveyors and others searched for a route through to the east coast of the South Island by crossing the "mineral belt" over what they called the Bare Spur at the head of the Maitai Valley. In doing so they were following an old track that, in addition to providing an overland route for Maori, also gave access to one of the largest pakohe quarries or more correctly group of quarries. Because of a nearby shallow pond it became known as the Rush Pool Quarry. A survey of the pool showed that it contained below a mat composed of roots of rushes, a layer of peat up to 2 m thick with on all but its southern side fairly vertical sides (Knapp, 1928) thus indicating that a poorly drained natural depression had been enlarged by Maori. The surveyor John Wallis Barnicoat (1814-1905) even recorded ruined Maori huts on the spur (Skinner, 1914: 326) and although travellers could not have missed seeing the huge flaking floors (Fig. 6), no one apparently recognised them for what they were. This was also despite a huge number of pakohe adzes being unearthed as the lowlands were brought into pasture. Farmers walking behind their ploughs picked up the adzes but little thought was given as to where they may have originally come from.

Figure 6. Flaking floor at the Rush Pool quarry with broken granodiorite hammer stones (centre).

One person who would have done so was the German geologist Ferdinand Hochstetter (1829-1884) who in 1859 was given leave from the Austrian Novara Expedition to remain in New Zealand, initially in Auckland Province in the North Island and then in Nelson. In New Zealand, Hochstetter was accompanied by Julius Haast (1822-1887), another German geologist. During their travels Hochstetter acquired a number of adzes, some of which he illustrated in his books (e.g. Hochstetter, 1867: 66). Both men in September 1859 visited Dun Mountain at the head of the South Branch of the Maitai River to examine the copper and chromite deposits and during which they observed mudstone that "is grey, cherty and fractured into small pieces". Hochstetter goes on to state that the "whitish-grey blocks of this rock are widely visible between the rusty yellow, serpentinous rocks (Fleming, 1959: 233). Hochstetter correctly interpreted that the rocks are "argillite included in the serpentinite and altered". Because the rocks were not as altered as at some other localities, such as the Rush Pool only 3 km to the north, they have never been worked by the Maori and consequently Hochstetter did not make the connection between the "mineral belt" and the adzes.

During their visit to Dun Mountain, as well as elsewhere during their two month stay in Nelson, Hochstetter and Haast were accompanied by a number of Nelson's leading settlers, who were also keen naturalists, as well as the geologist Thomas Ridge Hacket (1827-1884), local manager of the Dun Mountain Copper Mining Company. It is certain that if any of these men had been aware of the quarrying they would have informed Hochstetter who would have insisted that a short detour was made to the Rush Pool. Hochstetter did, however, recognise that part of Dun Mountain was not serpentinite but almost pure olivine that he named dunite. Haast came closer to seeing the evidence of quarrying for a few weeks after the Dun Mountain visit he was returning from, on behalf of Hochstetter, mapping the area east of the mountain and actually descended the Bare Spur on his way to Nelson. Unfortunately, by the time Haast and his companions reached the Rush Pool dusk was descending and they hurried on without stopping. Two years later the track was rerouted a little farther to the north and the one up the Bare Spur fell into disuse.

While Hochstetter and Haast were unfortunate not to come across the pakohe quarries on the Bare Spur, it is possible that a number of those in east Nelson were rediscovered soon after. In 1862 the Dun Mountain Copper Mining Company, formed to mine what later proved to be non existent copper lodes in the "mineral belt", directed its attention to extracting the chromite instead and the first large exports commenced from near Dun Mountain in 1863. While the demand for chromite remained high the search was on for other deposits elsewhere in the belt and it is possible that pakohe workings in the vicinity of several chromite prospects that had been found were recognised about this time. Certainly when there was a brief revival of interest in chromite in the late 1870s, following the discovery of a process of using chromium salts in the tanning of leather, several zones of mineralisation were found adjacent to significant pakohe workings, such as at Red Hill (Johnston, 1987). However, if quarries were found during these periods of prospecting, as seems likely, no record of them was made. In addition to the activities of the miners and prospectors, the hill country fringing the eastern ranges were being surveyed for settlement and as farmers cleared the vegetation, most commonly by burning, and hunted for wild pigs in the areas that were not torched, quarries were noticed and became more widely known. One such quarry in the Whangamoa Valley is now known as Hebberd's after the landowner (Wastney and Wastney, 1982: 11-12). Also many Nelson citizens had a pakohe adze sitting on the mantelpieces in their homes, and a few had made extensive collections, such as Edwin Herbert Lukins (1861-1931). However, it appears that such collectors were more interested in the finished articles rather than their origins.

There were, however, others who took a keen interest in natural history and were frequent visitors to the hills containing the "mineral belt". Frederick Giles Gibbs (1866-1953) was born in London and was ten when he arrived in Nelson. After graduating he taught at Nelson College before being appointed as headmaster of Nelson Boys' Central School. From an early age natural history frequently took him into the Nelson hills. In

particular, his love of botany meant the "mineral belt" held a double fascination, its unusual rocks giving rise to its unique vegetation. Undoubtedly the Bare Spur would have been visited frequently and in the early 1900s he and friends built a hut on the banks of the nearby North Branch of the Maitai River (Mann, 1977). He later wrote the botanical section of the "Geology of the Dun Mountain Subdivision" (Bell et al., 1911). Another teacher in Nelson who had similar interests to Gibbs was Frederick Vincent Knapp (1863-1945) and the two had also close professional ties as Knapp was for a time first assistant at the boys' school. However, Knapp's forte was Maori artefacts, particularly those that were not polished. Starting at an early age he amassed over his life time a huge collection that was dominated by unpolished pakohe woodworking tools and for which he attempted to interpret their use. Again Knapp in his younger years would have been no stranger to the Rush Pool and probably several other quarries. After his retirement in 1922 from the headmastership of the Nelson Girls' Central school he published a number of papers on the tools used by the Maori (Skinner, 1946).

Just when the existence of the quarries became known beyond Nelson is uncertain but in 1897 Captain Frederick Wollaston Hutton (1836-1905) director of the Canterbury Museum in Christchurch gave a presentation to the Philosophical Institute of Canterbury on Maori stone implements. Hutton was an outstanding scientist who was a Fellow of the Royal Society and had, after a short spell in the British Army, spent much of his career with the New Zealand Geological Survey before taking on a more academic role. In his presentation Hutton made a fleeting reference to the stone-implement quarries in the South Island, including those in Nelson (Hutton, 1897: 130). By now ethnology as a research subject was firmly established following the founding of the Polynesian Society in 1892, largely through the efforts of Stephenson Percy Smith (1840-1922). Percy Smith was born in England and arrived with his family in New Zealand in 1849 where they farmed in Taranaki in the west of the North Island. He became a surveyor, an occupation that fitted in well with his interest in all things to do with natural history as well as bringing him into contact with Maori in remote bush areas and whose contact with Europeans had been minimal. This kindled an interest in ethnology and, although he became Surveyor-general for New Zealand, it is as an ethnologist that he is now largely remembered (Byrnes 1993). Another with similar interests was Eldon Best (1856-1931), who as a member of the Armed Constabulary in the bush regions of Taranaki had first met Smith. He later accepted Smith's invitation to join the Polynesian Society. These two men, more than any others, firmly established ethnological studies in New Zealand. Despite authoring a major publication that appeared in 1912 on the stone implements used by Maori, Best only gave the pakohe quarries a fleeting reference.

The credit for the first detailed account goes to Henry Devenish Skinner (1886-1978), who in March 1910, presented a paper to the Otago Institute on the Rush Pool quarries (Skinner, 1914). Skinner, who had developed a fascination for Maori culture at a very early age from his father William Henry (1857-1946) a Taranaki surveyor. Skinner senior had spent most of his life in the province of his birth and, in doing so, gained first hand experience of Maori people living in a society yet to be markedly influenced by Europeans. He was a founding member of the Polynesian Society. His son quickly broadened his interest in ethnology and became aware of the Rush Pool when a boarder at Nelson College from 1902 to 1905. Although he qualified as a lawyer he decided on a career path more attuned to ethnology and when the family of his future wife moved to Dunedin, Skinner followed and it was there that he gave his paper to the Otago Institute. By the time it was published in 1914 he was acting curator of the University of Otago Museum and his eventful career culminated in his appointment to the directorship of the Otago Museum. Although Skinner observed at the Rush Pool granodiorite hammer stones, ranging from pebbles to boulders up to 25 kg in weight, it is likely that the presence of the pool, which he regarded as artificial, was instrumental in him postulating that a key part of the quarrying process was for an intense fire to be lit against a face and then rapidly cooled by water thereby fracturing the generally massive rock.

Five years after Skinner's paper was published another description of a pakohe quarry, this time one on the southern end of D'Urville Island, was forthcoming by James Allan Thomson (1881-1928), a geologist specialising in paleontology, and an exceptional man of science. After various positions, including with the New Zealand Geological Survey, he was appointed director of the Dominion Museum in Wellington. Still enthusiastic for fieldwork, he on the encouragement of Elsdon Best, who must have at the very least been advised of its presence, visited D'Urville Island where he was guided to the quarry by a farmer. Although finding no evidence of fire, Thomson accepted Skinner's inference that this was how the rock was quarried. More significantly, he observed that there were a large number of pieces around the quarry that, while of suitable size for making into tools, had been rejected. From this he inferred that they were of unacceptable quality and were from a superficial layer, up to about 0.3 m thick, of more weathered rock that had enclosed the better material (Thomson, 1918).

It was not until 1946 that the next report on the quarrying of pakohe appeared following an investigation by Roger Shepherd Duff (1912-1978) of the Hebberd's and Oakley's quarries in the Whangamoa Valley, intermediate between the Rush Pool and D'Urville Island (Duff 1946). Duff, who was a student of Skinner's, was the ethnologist at the Canterbury Museum (two years later he was its director). Like Thomson, the local farmers showed Duff the quarries, which were well exposed on land cleared of forest for grazing (following reforestation in the late 20th century the quarries are now overgrown and difficult to access, let alone observe). At the quarries, granodiorite boulders, probably from Cable Bay, of similar dimensions to those at the Rush Pool were present. This, and the lack of any evidence of the use of fire in the quarrying and that most importantly fire would have a deleterious impact on rock quality, led Duff to argue that use of granodiorite boulders as hammer stones was the sole method of obtaining suitably sized pieces of pakohe. Duff thought that the boulders would have been hurled from a high point at the rock below, but it seems likely that more controlled impact was invoked, such as having the boulder in a sling suspended from some form of gantry. The oval shape of the boulders would be consistent with such a practice. Since the pioneering descriptions of Skinner, Thomson and Duff a number of archaeological and ethnological studies have been completed (e.g. Jones, 1984; Keyes, 1975; Wellman, 1962), although much still remains to investigate. Unfortunately, the potential for getting a fuller understanding of this major industrial enterprise, particularly its early history, appears to be limited.

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