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## **Polynesian settlement of New Zealand and the impacts of volcanism on early Maori society: an update**

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### **Timing of Polynesian settlement**

#### **Models of settlement**

Various lines of evidence indicate that the 'homeland', or *Hawaiiiki*, of the early Polynesian settlers of Aotearoa was eastern Polynesia (e.g. see Sutton, 1994; Howe, 2003). Establishing the timing of settlement has been problematic, however. The most recent and reliable evidence, both from archaeological and natural sites, points consistently to initial settlement between c. 1250–1300 AD (called the late settlement model). Wilmshurst et al. (2008) suggested a settlement date of c. 1280 AD (see below). The application of tephrochronology to the issue is well established (Newnham et al., 1998; Lowe et al., 2000; Lowe and Newnham, 2004). The Kaharoa Tephra was erupted from Mt Tarawera in winter of 1314 ± 12 AD, as determined from the wiggle-match dating of a log of celery pine (tanekaha, *Phyllocladus* spp.) killed in the eruption (Hogg et al., 2003). It provides a key marker enabling both archaeological and palaeoenvironmental sites – which record the earliest forest clearances accompanying settlement – to be dated. The impacts on soils of Polynesian deforestation by burning are noted in a short article below (Lowe and McDaniel, this volume).

An earlier, transient contact at c. 50–150 AD, based on Pacific rat-bone (*Rattus exulans*) (known as *kiore*) dates obtained from avian predator sites, was proposed by Richard Holdaway (1996) on the premise that the rats, an introduced predator to New Zealand, accompanied the early Polynesian seafarers as a food source or stowaways. The results were very controversial because there is no supporting archaeological or ecological evidence for the presence of humans or rats in New Zealand until much later (c. 1250 AD). Holdaway has developed models involving the rapid spread of the rats over both islands and attributed the decline (possibly extinction) in some birds and other animals to predation by *kiore* well before c. 1250 AD. In 1987, Doug Sutton, formerly at Auckland University and now at Waikato University, had published a paper suggesting early settlement of New Zealand (approximately 0–500 AD) on the basis mainly of disturbance indicators in pollen records, primarily short-lived increases in bracken. That there was no evidence apart from the pollen record disturbances (just as easily accounted for by natural factors such as lightning, volcanic eruption impacts, or storms) was explainable according to Sutton by a tiny population which was 'archaeologically invisible'. Thus the 'old' rat-bone dates seemed to support his hypothesis (called the early settlement model).

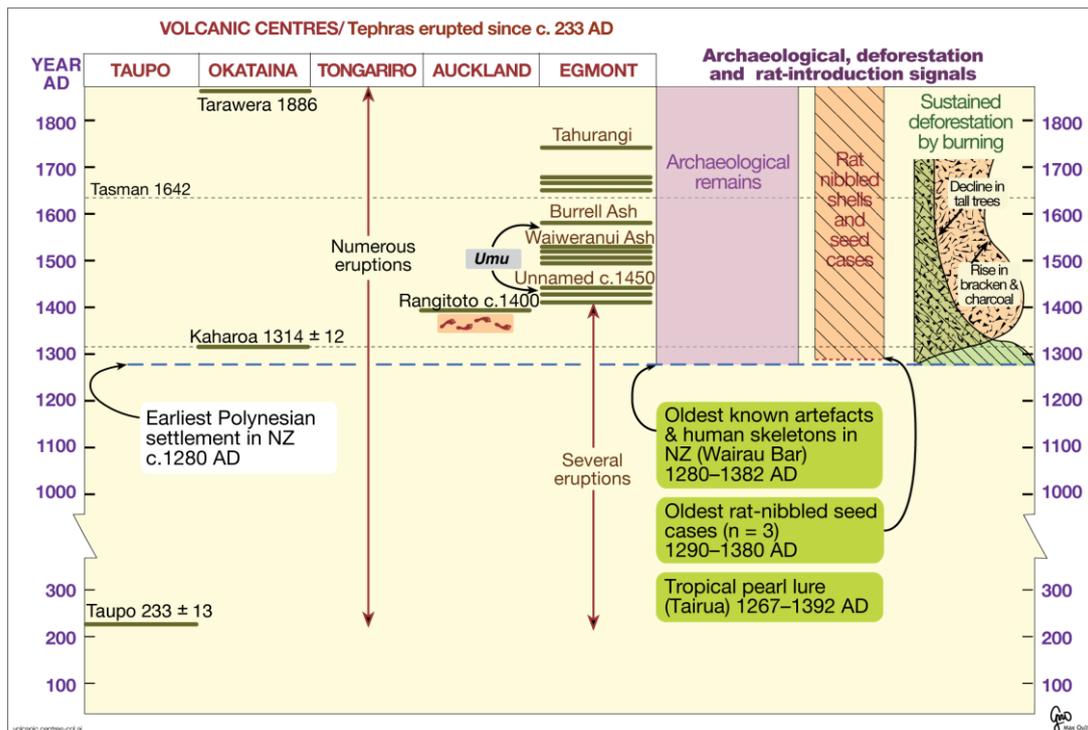
As well as lacking any archaeological or ecological evidence (such as change in vegetation as recorded by pollen profiles) for the 'early' arrival, problems with rat-bone ages had emerged during the dating of archaeological sites where ages of various cultural material (including charcoal, wood, eggshell, marine shell, and large bone) were all in good agreement with one another and with other sites, but rat-bone ages from the same layers were sometimes older by more than 1000 years. Critics suggested various explanations for the anomalously old rat bone ages. The most obvious thing to do was to re-date the 'old' rat bone material but it was reported, after a period of embargo by Te Papa, that no bone material was left. Thus, the question was: how to test the two competing hypotheses and especially to verify or otherwise the 'old' rat-bone ages? Janet Wilmshurst (Landcare Research, Lincoln) and Tom Higham at Oxford University (formerly at Waikato University) came up with two approaches. The first was to use an alternative method for dating the arrival of rats which

bypassed the need for bone dating. This was done by obtaining AMS (accelerator-based) radiocarbon ages on unequivocally rat-gnawed woody seed cases preserved in sediments. Wilmshurst and Higham dated numerous seeds at three sites, one on Coromandel Peninsula and two in Taranaki (i.e. opposite sides of North Island). The results were extremely clear: all rat-gnawed seeds were younger than about  $780 \pm 70$  cal. years old (Wilmshurst and Higham, 2004). The results at the Coromandel sites were confirmed by the unequivocal identification of Kaharoa Tephra there – just one rat-gnawed seed was found beneath the Kaharoa layer, but dozens were above it, all with young ages. The conclusion from this work was that rats arrived after c. 1250 AD, and not before. The rat-gnawed seed dates were supported by a similar study by Fred Brook who dated rat-gnawed landsnail shells in Northland: no snail shells had been nibbled before c. 1250–1300 AD (Brook, 2000). Together, the newly dated rat-gnawed seeds and snail shells (from widely spaced sites) showed that it was extremely unlikely that there were any rats in the North Island before c. 1250–1300 AD, but plenty after that date. Further studies at four coastal South Island sites showed all rat-gnawed seeds to be young, the maximum age obtained being  $702 \pm 32$  cal BP (Wilmshurst et al., 2008). From around 50 dated seeds in total, the oldest three gnawed seeds are dated at 1290–1380 AD (2 sd range).

The second approach was to re-examine independently the original avian predator deposits and collect new materials for dating and re-analysis. The results from one site were published by Anderson and Higham (2004) – that site was Earthquakes #1, north Otago, one of Holdaway's key sites. Anderson and Higham (2004) obtained two new radiocarbon dates for pigeon bones and two on rat bones: the pigeon-bone dates were as reported in the first series (i.e., 'young') but the two rat-bone dates were much younger than in the first series, suggesting that the 'old' rat-bone ages from that site were not reliable for estimating the timing of human settlement. Wilmshurst et al. (2008) have now collected rat-bone and bird-bone samples from other avian predator sites in the South Island, and obtained well-documented museum specimens, from Holdaway's original sites. All were dated younger than c. 1280 AD, the maximum age obtained on artefacts at the Wairau Bar, the oldest archaeological site known in New Zealand (moa egg shells found with human skeletons there are dated at 1280-1382 AD: Higham et al., 1999). Wilmshurst et al. (2008) thus concluded that initial Polynesian settlement of New Zealand was c. 1280 AD, and that the 'old' rat-bone dates of Holdaway (1996) were all flawed (irreproducible, too old). It remains possible, however, that Sutton's original model – that a small, environmentally and archaeologically invisible group of people arrived in New Zealand well before c. 1280 AD – is correct, but there is currently little firm evidence in support of it (see Sutton et al., 2008).

### **Impacts of volcanism on early Maori society**

Early Maori in northern New Zealand witnessed probably only one rhyolitic eruption (Kaharoa), two basaltic eruptions (Rangitoto, c. 1400 AD; Tarawera, 1886 AD), and numerous andesitic eruptions (dozens to possibly hundreds) from the frequently active volcanoes of Tongariro Volcanic Centre, Whakaari (White Is.), and Taranaki/Mt Egmont (Lowe et al., 2002). Eruptions from Tongariro, Ngauruhoe and Ruapehu, and from Whakaari, probably had relatively little direct impact because there were few or no people living near them. In contrast, minor or short-lived impacts on more distant communities within range of tephra fallout, especially in eastern North Island (e.g. Bay of Plenty, Hawke's Bay), would have been relatively common. Several eruptions, notably the Kaharoa event, the biggest eruption in prehistory, and some of the Taranaki events, including the Newall and Burrell eruptions, potentially had devastating consequences for relatively few people. Early Maori had a strong awareness of volcanism generally and may have developed a spiritual 'disaster culture' to reduce the impacts of eruptions in proximal locations. An initial response mechanism to avoid the effects of future natural disasters may have been the placement of a *rahui*, meaning prohibited access, on a devastated area. Subsequently, a more religious or superstitious restriction, or *tapu*, would be applied (Lowe et al., 2002). Further aspects of volcanism and Maori spiritualism were described by Cashman and Cronin (2008).



Summary of stratigraphy and ages of tephras, erupted from five volcanic centres since c. 237 AD, and their relationship with archaeological, nibbled seed/shell data, and deforestation signals in northern and eastern North Island (right) (after Lowe et al., in press) (note latest age estimate for Taupo eruption is  $237 \pm 4$  AD; Hogg et al., 2009). The Kaharoa Tephra provides a settlement datum for inferred human-induced burning and deforestation in much of northern and eastern North Island, matching the earliest settlement dates of c. 1250–1300 AD from many sites containing archaeological remains including the ancient Wairau Bar artefacts and skeletons (Higham et al., 1999) and the tropical pearl lure at Tairua (Schmidt and Higham, 1998), the oldest known rat-nibbled snail shells and seeds (Wilmschurst et al., 2008), and the earliest reliable dates for sustained deforestation elsewhere in New Zealand (Newnham et al., 1998; McGlone and Wilmschurst, 1999).

In contrast, other sacred areas were designated as accessible places of refuge or sanctuaries for all citizens (e.g. *marae*, a ceremonial meeting place). This interpretation has some similarities with Japan where Shinto shrines and their surrounds, which are sacred and inviolate areas, represent religious places both of worship and refuge that may have been initially established in safe zones in response to earlier natural disasters (Lowe et al., 2002). The beneficial and spiritual aspects of volcanism are numerous and include preferential occupation of volcanic cones as fortified villages, the use of volcanic materials (e.g. obsidian, pumice) for tools, geothermal activity for hot-water supplies, and the use of volcanogenic iron oxides (especially ferrihydrite) from seepages or soils as pigments for functional and ceremonial purposes (Lowe et al., 2002).

### Tarawera eruption and catastrophic impacts

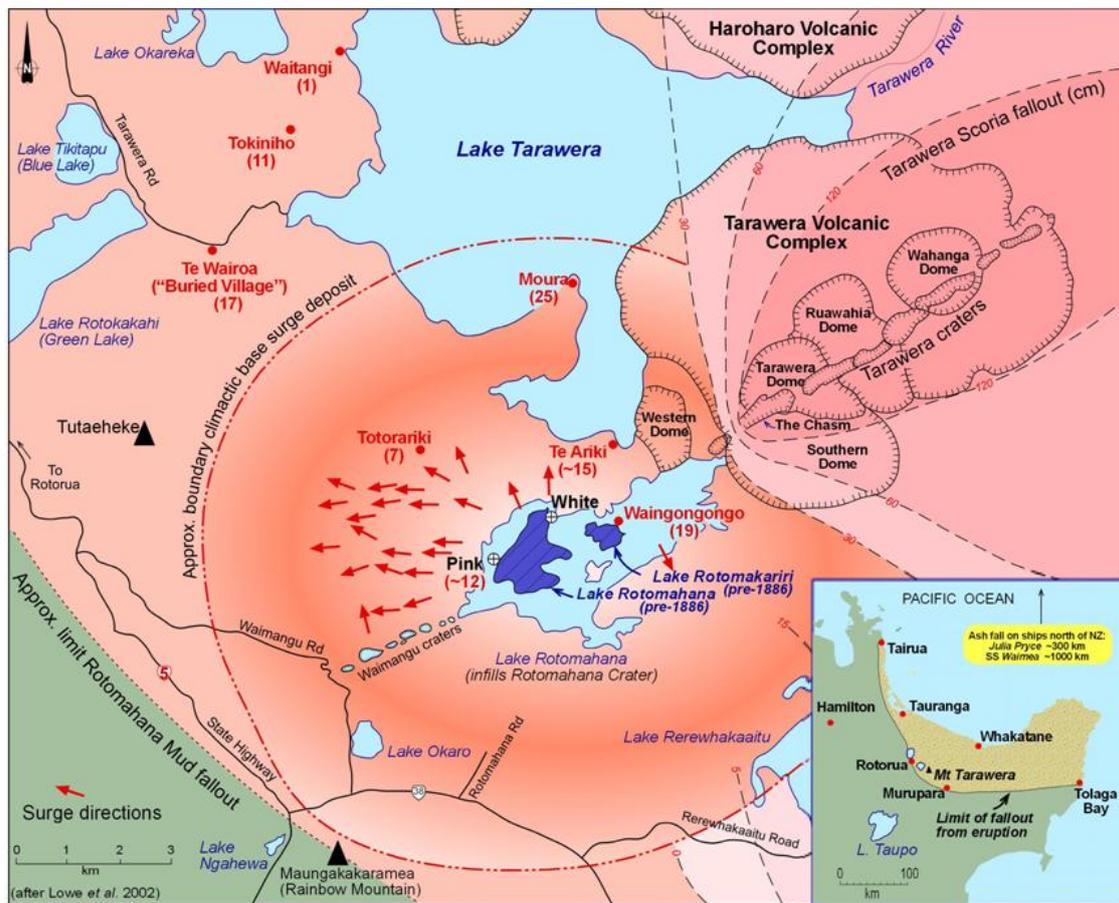
The Tarawera eruption of 10 June, 1886, was the biggest and most destructive eruption in New Zealand during the historical (European) period. It was a basaltic rather than rhyolitic event, but was nevertheless very explosive: the resulting scoria fall ('Tarawera Scoria') has a dispersal similar in extent to that of the Vesuvius 79 AD pumice fall and is one of the few known examples of a basaltic deposit of plinian type from a fissure source (Walker et al., 1984; see also Sable et al., 2006; Carey et al., 2007). The eruption cored out a series of craters in a 7-km-long fissure through the antecedent rhyolite domes (including those emplaced during the Kaharoa event) of Mt Tarawera, and then generated more craters along an 8-km-long southwest extension of the fissure across the Rotomahana basin (which contained two shallow lakes and large silica sinter aprons, the 'Pink' and the 'White' terraces, associated with extensive hydrothermal activity) to Waimangu.

Narratives (summarized authoritatively by Keam, 1988) indicate that after a series of precursory earthquakes from ~12.30 am, the eruption began at Ruawahia Dome at about 2.00 am on 10 June, 1886, and then gradually extended both northeastward and southwestward. At ~2.10 am the eruption intensified with the ascent of a tephra plume from the vicinity of Ruawahia Dome up to ~9.5 km. By 2.30 am craters along the whole length of the fissure were erupting, with the Rotomahana extension beginning to erupt possibly at ~3.20 am. By 3.30 am, craters along the entire 17 km-length of the fissure from Wahanga to Waimangu were in eruption. This paroxysmal stage of the eruption was over by 6.00 am when most activity ceased.

The erupted products were exclusively pyroclastic (no lava flows were generated, although basalt dikes were emplaced). The total volume (as deposited) of Tarawera Scoria is ~2 km<sup>3</sup> (Walker et al., 1984). The eruption along the Rotomahana and Waimangu extension was mainly phreatomagmatic (interaction between basalt magma and hydrothermal water) and phreatic. The explosive expansion of superheated water fragmented the country rock containing the hydrothermal system, plus subordinate lake sediment, to produce surge beds and fall deposits ('Rotomahana Mud') that rained out over much of the Bay of Plenty and beyond (~0.5 km<sup>3</sup> as deposited). Near Rotomahana, the surge beds were emplaced violently by hot and fast-moving turbulent pyroclastic surges or density currents up to ~6 km from source (Nairn, 1979). Lightning during the eruption set fire to a house in Te Wairoa and to the forest on the north shore of Lake Tarawera; strong winds flattened many trees at Lake Tikitapu; and suffocating gases and falling mud and ash made breathing difficult at Te Wairoa, where most buildings were buried or collapsed under the weight of ~1 m of mudfall. A notable exception was *Hinemihi*, a large meeting house where most survivors were sheltered, because wooden forms for seating guests during Maori performances were used to prop up the roof.

All but seven of the 108 known fatalities arising from the Tarawera eruption were Maori (the true number of deaths may have been ~120, but the oft-cited ~150 is erroneous). The majority of deaths were the result of the Rotomahana explosions, especially the lethal, scorching pyroclastic surges and blasts. Clearly the event had a profound impact on Maori (and others) in the Te Wairoa and Rotomahana area especially, but trauma was felt throughout the extensive fallout zone in the Bay of Plenty and eastern North Island (Keam, 1988). For example, some groups of Maori in the region of the Rangitaiki and Tarawera rivers, north of Tarawera, became refugees at Matata. Although they had escaped with their lives and without serious injury, their possessions were buried by ~15–30 cm of tephra (some were retrievable by excavation), many potato pits were lost and those with livestock had no feed for them and so many starved (Keam 1988; Lowe et al., 2002). These people were eventually resettled in 1903–1905. The plight of these and other Maori seem minor in comparison with the difficulties of those from Te Wairoa-Rotomahana: apart from the lives lost, all possessions had been buried and many crushed. Among livestock, most smaller animals were killed, but dogs, pigs, cattle and horses that survived wandered loose and starving. The main livelihood of the region, tourism, had been destroyed, literally overnight. (Whilst Maori continued to participate in the tourist trade, its control effectively moved into European hands from 1894 with the opening of the railway line to Rotorua.) However, perhaps the biggest societal impact, according to Keam (1988), was the loss of land. For thirty years, Maori groups in the region had been generally secure in possession of their land and property. In previous times, under the old order, the prospect had always existed that a group might lose homes and land through warfare, but by the time of the Tarawera eruption, the people, long-established traders with European settlers, had become accustomed to a newfound security. The eruption rather than warfare (against which there could at least be retaliatory or conciliatory action to make-good losses) had destroyed that security and dispossessed the people of the land, which they had prized most. Offers of resettlement for the surviving group, mainly the Tuhourangi subtribe or clan (*hapu*), were received from various parts of central and eastern North Island and beyond, but most settled at Whakarewarewa and Ngapuna, both near Rotorua. Eventually gifts of land were formally ratified and provided a home for most of the Tuhourangi people. Other Tuhourangi settled for a time in the Bay of Plenty and Coromandel. After 30-50 years

almost all the refugees or their descendants had returned to Whakarewarewa or Ngapuna and the gifted land was returned to the donors (Keam, 1988; Lowe et al., 2002).



Map of Tarawera area showing locations of the main craters of the 10 June 1886 fissure eruption across Tarawera Volcanic Complex, Rotomahana Crater (including pre-eruption lakes Rotomahana and Rotomakariri), and Waimangu craters (after Lowe et al., 2002). Locations of villages and associated fatalities (numbers in parentheses) are based on Keam (1988) (there was an additional death at an unknown locality). Fatalities were all Maori apart from six Europeans at Te Wairoa and one European and three (part) Maori at Waingongongo. On the night of the eruption nearly half of Te Arika's 27 residents were camped at Pink Terrace (Otukupuarangi). Inset shows eastern North Island and documented limits of tephra fallout from the eruption (based on maps by A.P.W. Thomas, 1888). Ash fell on several ships at sea, the farthest being *Julia Pryce* (c. 300 km) and *S.S. Waimea* (c. 1000 km) north of North Island (Keam, 1988).

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