The June 1846 Eruption of Fonualei Volcano, Tonga
An Historical Analysis

by

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Introduction

This report forms part of a research program to demonstrate the use and value of historic data in contemporary environmental and disaster management in the Pacific. Hindcasting events based on historic records is a valid endeavour in order to add to the database of occurrences. This is particularly the case with climatic events such as typhoons, and geophysical events such as earthquakes, where the estimation of risk is based on the understanding of the recurrence interval of the hazard. In the absence of deep time scales in many parts of the Pacific, historic reanalysis of data is a relevant tool.

This report compiles and discusses the historical evidence for an eruption of Fonualei Island, northern Tonga Group, in June 1846 and expunges some erroneous interpretation of data from the record.

The Island

The Tongan islands lie on the NNE-SSW trending, mostly submarine Tonga-Kermadec Ridge, which constitutes a major bathymetric feature extending over 1300 km from New Zealand to Samoa, formed by the subduction zone of the Pacific plate sliding under the Indo-Australian plate at a speed of ~100 mm per annum (Lewis 1985). They consist of three types of islands running in two island chains parallel to each other and the at times 10,500 m deep Tonga trench.

i) An eastern chain of islands, sitting on the relatively shallow forarc platform (the Tongan Frontal Arc), consists of reefal coral limestone underlain by older volcanic rocks (Tongatapu, Ha'apai, Vava'u). In some instances the underlying volcanic rocks are exposed, such as on Nomuka and 'Eua. On the latter island these rocks are of Eocene origin.

ii) A western chain of active volcanoes (e.g. Tofua, Late, Kao) sits on the Tofoa Ridge and is separated from the chain of coral limestone islands by a trough up to 1,800 m deep.

iii) A chain of active submarine volcanoes, which erupt spasmodically and form unstable islands consisting of volcanic ash and pumice (e.g. Fonuafo'ou [Falcon or Jack-in-the-box I], Metis Shoal), coincides with the chain of visible volcanoes.

Traditionally, the islands of coralline origin, such as Tongatapu, the Ha'apai Group and Vava’u, were the centres of human settlement, with smaller populations resident on 'Eua as well as Niutoputapu and the smaller volcanic island of Niuafo'ou (Spennemann 1988; 1992; 2002; 2003a). The soils of the main islands are all derived from tephra.
Figure 1
Map of the Tongan Group
On the larger islands multiple soil series can be found, caused by multiple deposition events, thereby demonstrating multiple eruption events. Moreover, on the larger islands the thickness of the younger soils decreases from west to east, indicating an origin of the tephra from a source in the west, against the prevailing trade winds (Cowrie 1980, Orbell 1971; 1977a–b; Wilson & Beecroft 1983; Wilson & Hewitt 1983).

**Historic record of volcanic eruptions**

Possible volcanic ash deposits have been found in one archaeological site on Tongatapu (site TO-Pe-5/TO.5; Poulsen 1987, vol. I p. 33-34) as well as on a site ‘Eua (Spennemann 2002). While on ‘Eua the spatial position of the site in relation to palaeo shore lines (Spennemann 1997) and the topography of the island may indicate an massive erosion event and land clearing (Spennemann 2002), the evidence for Tongatapu suggests a different origin, possibly an airfall ash deposit. The lie of the land is too flat to allow for erosion to deposit the 5mm thick layer of bright brown tephra. The layer is lacking in the northern part of the site, which could have been exposed to wave decay. If the interpretation as a volcanic ash deposit is correct, then we can date a small ash shower to between 3200BP (the establishment of the shoreline; Spennemann 1987) and about 350 and 550 AD (a fire place Poulsen 1987; Spennemann 1989; Spennemann & Head 1998). Stratigraphically it is closer to the latter date. The thickness suggests a substantial ash shower.

With the advent of European visitation we have records for volcanic eruptions, the earliest being the eruption of Tofua noted by Cook on his third voyage (1777). Well known are also the various eruptions of Niuafou‘ou (cf. Rogers 1987) and the erratic occurrence and disappearance of Fonua-fo‘ou.

Volcanic eruptions have been recorded for Late Island (1854), Tofua Island (1774, 1906, 1959), Fonuafou‘ou (pre-1781, 1885, 1927), Fonualei (this report) and Niuafou‘ou (1886, 1929, 1943, 1946, 1947). In addition to these, various submarine eruptions have been recorded (compiled after Wood 1932; Lewis 1978; 1979), some of which have generated unstable ash-derived islands such as Fonuafou‘ou or Falcon I. (< 1781, 1884-1887, 1927-1930) (Compiled after British Admiralty 1889; 1896; Firth & Davidson 1944:28; Hoffmeister & Ladd 1928; Lewis 1978; Marden 1968:367; Thomson 1926:367; Wharton 1890).

**Toku**

Toku, located at 18°15' S 174°18' W, is a small volcanic island. It has an area of 0.4 km² and a total elevation of 16m (UNEP 1988) Wood (1932, p. 107) gives an area of 150 acres with a maximum elevation of 86 feet.

The Pacific Islands Pilot (1956, p. 424) describes Toku as a small and low island.
In the 1830s Toku had served as a refuge island for refugees from the village of Ha’amea on Tongatapu, who had left due to fighting. The people lived on Toku but had gardens on Fonualei. Following the eruptions discussed in this report, the people of Toku resettled to Utulei on Vava’u (Wood 1932, p. 74).

In 1889-90 J.J. Lister travelled to some of the islands on HMS Egeira. According to Lister (1891, map) Toku was 82 high.

*Fonualei*

Fonualei is located at 18° 01' 0S 174° 10' 60W. The island is a stratovolcano with a maximum elevation of 180 m. Wood (1932, p. 107) gives an area of 465 acres with a maximum elevation of 600 feet.

Francisco Antonio Maurelle was the first European to sight Fonualei on 26 February 1780 (Maurelle 1798, p. 269). The French Explorer La Perouse acquired a copy of Maurelle’s observations and quotes him extensively as follows:

> “On the 26th of February I saw a small island, and stood towards it in the hope of being able to come to an anchor there, and procure water. The crew leaped for joy, as if this island were to put an end to all their restrictions. Their hilarity equalled the distress to which they had been reduced; but it was of short duration: for when we arrived within two miles of it, we saw clearly, not only that there was no anchorage, but even that a boat could not land on it. It was beside perfectly barren on it’s mountain, which was by no means small, not a single tree was to be seen. The island, from the anguish of our disappointment, we called Amargura, Bitterness.” (Maurelle 1799, pp. 277-278; 1807, pp. 277-278).

La Perouse himself sighted Toku and Fonualei on 27 December 1787, but his descriptions are very brief:

> “I saw Morel’s Margoura bearing west from me and coming nearer I sighted a second very flat island, covered in trees, which this navigator had not seen; by contrast Margoura is fairly high and it is likely that both are inhabited; after taking our bearings I made for Vavau Island…” (La Perouse 1799, p. I 122-123; 1807, pp. I 122-1-123; 1995, p. 434).

Fonualei was also seen by Captain Edwards of HMS Pandora, searching for the Bounty mutineers. Edwards called the island ‘Gardner’s Island’ (Finlay 1863, p. 403). Fonualei was visited on occasion by whalers, but it is not known if any of them actually landed. Between 23 and 26 of October 1836 the whaler Richard Mitchell, sailing in company with the whaler Independence, was in the waters around Fonualei, sighting the island on the 23rd, 24th and 26th (Smith 1839). On no occasion was an attempt made to land.

In 1848 the island was visited, again without an attempt to land, by Captain Worth commanding HMS Calypso (Finlay 1863, p. 403).

The Pacific Islands Pilot describes Fonualei as follows:
“Fonualei.-Fonualei (Fanua lai), an island about 11 miles north-north-westward of Toku (Lat. 18° 09' S., Long. 174° 11' W.), rises to a sharp and well defined summit, 600 feet (182m9) high, which falls abruptly to the sea on its southern side in light-grey-coloured cliffs. The coast is clifffy, except on the north-western side, where there is a small bight with a sand and shingle beach, on which landing is possible in fine weather. There is a narrow fringing reef on the northeastern, southern, and western sides.

Northward of the peak, which is the summit of a small ridge running east and west, covered with vegetation, the land slopes down. It rises again on the western side of the island to a wide, barren, lava-streamed ridge, 500 feet (152m4) high; on the eastern side a lower ridge, from which a faint column of smoke was observed to rise, in 1898, follows the coast, terminating in a summit, 370 feet (112m8) high, near the northern end of the island.

The hills form the walls of a crater, a small portion of which has been blown out on the north-western side, thus giving access to the crater from the beach on that side. The valley so formed in the interior is cultivated, but no inhabitants are permitted by the Tongan Government to reside there on account of its liability to eruption. The island is visited occasionally by natives from Vava’u” (Pacific Islands Pilot 1956, p. 425)

Bryan et al (1972) provide a map of Fonualei (Figure 2)

Eruptive History of Fonualei

According to the published record, the eruptive history of Fonualei commenced in 1847 “when the island was in part destroyed by the eruption of its crater” and “ashes were thrown in large quantities on passing ships 500-600 miles to the N.E. (Findlay 1871, p. 456). Findlay’s notes were carried through to the early geological references, such as Lister’s ‘Notes on the geology of the Tonga Islands’ (1891) and from there found their way into standard references.

The current appearance of Fonualei is defined by a caldera that is breached on the eastern side, while capped on all other sides by volcanic ash intermixed with pumiceous fragments (Bryan et al 1972). Rough, blocky lava flows, extending from a cone in the caldera to the northwest and east have been attributed to the 1846/47 eruption events (US Naval Oceanographic Office 1952., p. 159 cited after Bryan et al. 1972). Additional flows and ash deposits can be attributed to the 1939 eruption, while the 1943 event was reputedly more limited.
Figure 2. Map of Fonualei in 1971
(Source: Bryan et al 1972)

Figure 3. The central crater of Fonualei photographed in 2003
(photo Dick Watling, Source: courtesy Birdlife International)
Figure 4 Map of Vava'u, Toku and Fonualei
According to the Smithsonian website,

“The small, less than 2-km-wide island of Fonualei contains a fumarolically active crater, which is breached to the SW with a fresh lava flow extending to the sea and forming a rugged shoreline. Steep, inward-facing scarps mark the rim of a partially exposed caldera which contains a pyroclastic cone that is breached to the east and forms the 180-m-high summit of the island. Blocky lava flows from this cone fill much of the northern caldera moat and reach the sea through notches in the northern and eastern caldera rims. In contrast to the basaltic and andesitic rocks of other islands of the Tonga arc, Fonualei lavas are of dacitic composition. Eruptions have been recorded since 1791, with the two largest taking place in October 1846 and July 1847. Lava flows occurred in both these years; in 1846 explosive eruptions produced large pumice rafts, and the following year ashfall damaged crops on the island of Vavau (56 km away) and fell on vessels up to 950 km distant. In 1939 explosive and effusive activity occurred from summit and flank vents, and water spouts were reported 1.6 km SE of the island.”

The Sources

The data presented here on derive from a number of sources, whaler’s logbooks and newspaper items. Fonualei and Toku are of minor importance in the Tongan settlement history, and thus do not figure in the main reports such as Mariner’s account (Martin 1817).

The Samoan Reporter

Well before the first commercial newspaper was published in Apia in 1878 the London Missionary Society published a news sheet between 1845 and 1860, The Samoan Reporter (Spennemann 2003b). Appearing biannually, the Samoan Reporter was a four, and on occasion six page paper set out in three columns and printed locally at the London Missionary Society’s printery at Leulumoega on Upolu, Samoa.1 It carried missionary news, some general news items, as well as a serialisation of ethnographic observations.

The main account of the eruption (see Appendix 1) was first published in that source.

1 In total twenty-one issues are extant.—Printed by John Bettrige Stair: n° 1, March 1845; n° 2, September 1845; n° 3, March 1846.—Printed by James Povey Sutherland: n° 4, September 1846; n° 5, March 1847; n° 6, September 1847; n° 7, March 1848; n° 8, September 1848; n° 9, March 1849.—Printed by Samuel Ella: n° 10, November 1849 (6 pp); n° 11, July 1850; n° 12, January 1851; n° 13, July 1851; n° 14, September 1852; n° 15, January 1854 (6 pp); n° 16, December 1854 (6 pp); n° 17, January 1856; n° 18, January 1857; n° 19, October 1857 (6 pp); n° 20, lacking n° 21, March 1860 (6 pp);
Other newspapers

Reports on the success and failure of whalers operating in the Pacific were important news items for the newspapers in whaling ports of New England. Many of these papers relied on letters sent by captains or crew of the whalers, and also material abstracted from Sydney and Honolulu newspapers. In addition, copying of text items from other New England papers was common, with or without crediting the sources.

As part of a labour-generation scheme during the New Deal period, references to American activities in the Pacific have been extracted from these papers. They have been published in 1967 (Ward 1967).

Missionary Accounts

We have in hand one published account by the Wesleyan missionary Walter Lawry (1850, p. 14) who visited the island en route to Fiji. Because it is ‘off the beaten track’, little has been recorded by standard missionary sources.

Naval Accounts

In addition to the Missionary accounts we have a number accounts by British naval commanders, such as Erskine’s 1853 publication on his voyage in HMS Havannah,

Whalers’ Logbooks

The greatest number of European vessels plying the Pacific Ocean at that time were whalers. The logbook entries range from the laconic, just stating position and winds, or banale information (“arrived 'Eua, off 'Eua, departed 'Eua”) to truly elaborate multi-page descriptions of islands and their inhabitants. Usually such entries are confined to the first year of the log-book keeper’s voyage. Logbooks were kept by Captains, but also by some of the mates for future reference when they were to have their own command. Each logbook provides the position of the vessel ‘shot’ at noon. Thus a ship’s day ran from noon to noon, broken up into three watches or ‘parts’ (‘first,’ ‘middle,’ ‘latter’). Depending on the habit of the logbook keeper, the noon-time position would be recorded at the beginning or the end of a day. Care must be exerted to interpret these data correctly. If entered at the beginning, the position can be taken at face value for the calendar day (unless the logbook keeper forgot to take leap years into account or made other mistakes). If entered at the end of a day, the noon-time position actually refers to noon of the day following the date of the entry.

Commonly used source information

The main source, which was drawn on by many geological reports, is the entry by Alexander Findlay in his Directory for the navigation of the South Pacific Ocean:
“In April 1847 Amagura was destroyed by the eruption of its crater, which according to the Rev. Mr Lawry was heard at Nina Fo, 160 miles distant, and it damaged the crops and trees at Vavu, 35 miles off. Ashes were thrown in large quantities on passing ships, 500 and 600 miles to the NE.” (Findlay 1863, p. 403; 1871, p. 456; 1874, p. 456; 1877, p. 511).

This, however, is a misrepresentation of the true facts, which shall be discussed below.

The Eruption of 11 June 1846

Perusal of The Samoan Reporter of March 1847 finds the following statement on a volcanic eruption on an island northwest of Vava’u (Mills 1847a, for full text see Appendix 1):

“... a new Volcanic Eruption at a small uninhabited Island... Toku is the proper name, but known on the Charts as Amagura. ...

On Tuesday the 9th of June [1846], and two following days, severe shocks of Earthquakes were felt at Vavu, during every 15 or 20 minutes. They could be easily perceived on board the vessel lying at anchor in the harbour. On the night of the 11th bright flashes of light were perceived in the direction of Toku, reflected against the heavens, but at a very high angle.

On the morning of the 12th every thing was covered with a thin dust... A strong suffocating smell of sulphur was perceived.

Mr. Williams left Vavu on the 13th the Island of Toku lying nearly in their course. As they approached it, they could perceive immense volumes of smoke and dust ascending, as they came still nearer to it, they could form some idea of the immense extent of the crater, which is described as being of very great diameter.

... About 2 o'clock, on the morning of the 12th, and at least 3 degrees in a N. E. direction from Toku, Captain Samson of the "Charles W. Morgan," ... entered a shower of ashes. ... so soon as they got into it, ... the deck began to be covered with the fine dust. ...So soon as the sun arose, the dust appeared of a dark red colour, rolling over like great volumes of smoke, presenting an awful appearance ; at 8 o'clock it was so dark that candles had to be lighted in the cabin ; at 11a. m. it began to clear a little, the sun appearing occasionally. By noon they had got out of it, being then in 171º 45 W. and 11º 2 S. having sailed across the shower at least 40 miles. Captain Cash of the Ship "Massachusetts" got into the shower about the same time, though at least 60 miles to the East of Captain Samson, and not far from Savage Island [Niue, Ed.].

...The dust is of a dark grey slatey colour. Of specific gravity 1.076. containing a large proportion of Sulphur, and so much of free Sulphuric acid as to give it a sharp taste. It also contains a small proportion of iron.”
The reference to the chemical composition of the ash as included in the account shows that Captain Samson had the presence of mind to collect a sample. We do not know who analysed it and whether it was sent to other analysts.

The same text (as shown in appendix 1) also appeared in the Honolulu-based paper *The Friend of October 1847*, which reprinted the *Samoa Reporter* item in full (Mills 1847b). The Samoan item was also independently picked up and abstracted by New England newspapers, such as the *Boston Daily Evening Transcript* (Anon 1847a).

The evidence in *The Samoan Reporter* can be collaborated by a consultation of the logbook of the *Charles W. Morgan* (Vincent 1848). The *Charles W. Morgan* had come to Tonga to trade for live stock and provisions, and had achieved this on 2 June 1846 on 'Eua, an island just east of Tongatapu (Vincent 1848), then a favoured spot for whalers to replenish their supplies (Spennemann 1987a–b). The *Charles W. Morgan* then made sail for the Central Pacific, sailing to the east of Tongan Chain. Based on the noon-time positions reported in the logbook (see Appendix 2) the track of the vessel can be plotted (Figure 7).

On 12 June the *Charles W. Morgan* encountered the ash cloud. The logbook entries read (spelling retained):

> “Friday June the 12 1846 | Begins with fine trades from S.E. and steering | by this wind N.N.E. the middle part the | same and nothing of note | Lat 18..02 Long 171..20 W | to day we got in to a Sand Mist and saild in it 9 | hours it

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2 Source: www.worldshiptrust.org/AwardCharlesMorgan.html
being very thick & fild the rigging & sails full | & the ship lookd enough to frighten any one

Saturday June 13 1846 | Begins with light trades from E.N.E | heading to the North at 4 A.M. the Ship got in to a Sand Mist and we said | through it 9 hours it being very thick | Lat 17.22 S Long 171.20 W.”

From perusal of the logbook it would appear that the Charles W. Morgan encountered two distinct ash clouds. Given that the time spent in the ash cloud on both days was nine hours, it is most likely that this is a double reference to the same day, the 12th of June.

While logbooks exist for a number of voyages of the whaler Massachusetts, mentioned in the Samoan Reporter, no logs for 1846 are available. Thus the positions and experience of the Massachusetts encountering the ash cloud cannot be assessed. Yet the experience cannot have been very remarkable, for when 17 June 1846 the Massachusetts arrives on Upolu, the log of the whaler Christopher Mitchell narrates events aboard the Massachusetts, mainly a whale hunting incident, but makes no reference to an ash cloud (Ackley 1848).

**Toku or Fonualei?**

The account in the Samoan Reporter specifically mentions that the island erupting was Toku or Amargura using both names synonymously. Yet, so far no record for an eruption of Toku can be found in the records. What is described in the volcanological literature, however, is an eruption on Fonualei in October 1846 and one in June 1847. It appears that these two events have been extracted from G. Ward’s collection of US newspaper reports on American activities in the Pacific (see Appendix 3 and 4). The reference to the 1847 eruption seems to derive from a summary (Anon 1847a) and a full reprint (Mills 1847b) of the account originally published in the Samoan Reporter of March 1847, as well as a summary of the events published in Findlay’s widely used Directory for the Navigation of the South Pacific Ocean (Findlay 1863, p. 403). As both the extract and the reprint make no reference to a year, a casual reader is forced to assume that both accounts refer to June 1847.

Consulting indices of Pacific Islands (Brigham 1900, p. 67; CIA 1957, p. 359), Amargura is clearly a synonym for Fonualei, so named by Francisco Antonio Maurelle in 1780.

**Other Sources**

A perusal of a list of known shipping in the Tonga Group (Spennemann 1987b; in prep) showed the presence of other vessels in the area at roughly this point in time. The eruption may have been preceded by earthquakes, but no major fumarolic activity. The whaler Alfred of New Bedford, Captain John Davenport, saw the island during the day and night of 20 May 1846. The log makes no comment on smoke or eruptions (Davenport 1849).
One further whaler’s log can be drawn on, and this one provides significant additional information. The whaler Minerva, commanded by Captain Joseph Bailey, was also replenishing at ‘Eua in mid June 1846, Like the Charles M. Morgan it made sail for the Central Pacific, on the 21st passing some 10 nautical miles north of Vava’u. On the 22nd of June they reached a small volcanic island. As the Minerva recorded its noon time positions at the end of the log-book day, the position of the log entry for the 21st was in ‘real time’ just before noon on the 22nd. The Minerva’s position was 18º05’ south, with no longitude given. The logbook entry for the 22nd of June reads:

“Monday June 22nd
Steering in SW for Amagura. At 3 | lowering away a boat and went on shore to see a volcano. It was | about 160 feet high and as much in diameter looking like a large pile | of stones with an immense fire under it. There was eruption every | few minutes when immense boles [?] of steam and stones were thrown | to a great height. We’ve ventured within about 25 feet of it between | spells. There was water flowing almost round it. The whole island | was volcanic. One place a quarter of a mile from the crater | the smoke was flung out. Ground covered with sulphur | Middle part steering S by W. Main Top G[allant] sail set. 15º39’ 175º20’.”
(Bailey 1846).

Again, Amagura is specifically mentioned. Most significantly, however, are the dimensions of the volcano. The island is described as 160 feet high and about the same in diameter. All accounts of Fonualei describe the island as about 580 to 600 feet in height. There can be little doubt that the island could have grown through subsequent uplift or volcanic activity.

The Wesleyan missionary Walter J. Lawry conducted a tour of inspection of the Wesleyan missions in Tonga and Fiji in 1847. The volcanic eruption was significant enough to figure in the published account:

“Tuesday August 17th, 1847 At sea en route to Niua… Funua-lei presented the most awful and terrific appearance in the form of a natural phenomenon, that it had hitherto fallen to my lot to witness. It was a circular and rather high volcanic island, about ten miles round, until, of late, when it became so frightfully convulsed that it was turned inside out, and split in two parts! God had sent such clear warnings by the heavy earthquakes which preceded this eruption, that the people had left the place and had gone to Vava’u, where they are now living. To us on our ship’s deck it presented an appearance of desolation, which filled us with awe, and caused a sigh to escape from every beholder. The sailor, the native Teacher, the Missionary all exclaimed, “Come and see the desolations which the Lord hath made!” The idea it impressed upon our minds was that of a ruined world. It smelled very strongly of sulphur, and exhibited rents, and piles of burnt sand and vitrified matter, as if the bowels of the earth had been turned outside. Volumes of smoke were pouring forth at twenty places, sometimes closing here and opening there. The openings of crater after crater were seen in all directions, and the sea, for a great distance, was discoloured by the floods of lava poured forth. The light of
the flame caused quite an illumination at Vava’u, distant thirty-five miles; and the noise of this fiery disgorge was distinctly heard for three successive days at Nina Fo’on, distant one hundred and thirty miles! The dust and vitrified matter were discharged from this deep volcano to such a height, that we saw much of it and its withering effects, thirty-five miles off, at Vava’u, where the damage was very considerable, both to the trees and to the crops generally.”

[An excerpt from the text printed in the Samoan Reporter is omitted, Ed.]

For many weeks before, as well as at the time of this disruption, the earthquakes for a space of fifty miles around, and especially at Vava’u, were truly terrific, and, even now, they seldom miss shaking every moon. About a year since, this oceanic mountain was covered with verdure, and abounded with fruit-trees; but, behold, it has now become a bare mass of lava and burnt sand, reduced from a fine cone to a divided an ghastly heap of scoria and black powder, without a leaf of a blade of grass of any kind, and all things living are destroyed. Such at present is Funua’le’i, a monument to God’s power to create and destroy.” (Lawry 1850, p. 14)

John Elphington Erskine, commander of HMS Havannah, visited Vava’u on 30 and 31 July 1848. He comments:

“Earthquakes are very common; and there are several active volcanoes in the neighbouring islands. Amargura, or Fonna-la’i, in about 18°S latitude, is said to have been so shaken by an eruption in June, 1846, that canoes can now sail in and out of the crater; and the Revd. Lawry describes the islet, which until that year was covered with verdure and abounded with fruit, as reduced in August, 1847, to a huge mass of lava and burnt sand without one leaf of blade of grass of any kind. All things that had life had been utterly destroyed, the inhabitants having, however, warned by violent earthquakes which preceded the eruption, happily escaped previously to Vava’u. Mr Lawry adds that the noise of the fiery disgorge was distinctly heard at Nina Fo’on, distant one hundred and thirty miles; and that its withering effects on the trees and crops, which it damaged considerably, were experienced at Vava’u, thirty-five miles off [Erkine footnotes that the distance was 60 miles, Ed.]. An American ship, the Charles W. Morgan had sailed through a shower of ashes for forty miles, getting out of it in lat 11°02’ S and long 171°45’ W; and another (the Massachussetts), at the same time, although sixty miles further to the eastward, had the deck covered with ashes, which the crew were obliged to clear from time to time.” (Erkine 1853, p. 120).
Ash or pumice?

The above quoted log book of the Charles Morgan makes mention of the pumice cloud that was traversed on 12 June 1846. Other whalers in the area were the Minerva, as mentioned (Bailey 1846), as well as the Charles (Coane 1848). The latter sailed through the area formerly covered by the ash cloud in July, some four weeks after the eruption (Figure 6). It’s log makes no reference of pumice rafts or the like.

This is not surprising, however, given that the pumice would have fallen closer to the volcano and given that in this area an ocean current runs to the west-northwest. In view of the current, the logbooks of those whalers were also checked.
which are known to have been in waters immediately to the west of the volcano (according to Langdon 1984). Consulted were the logs of the whalers *Alfred* (Davenport 1849), *Kingston* (Ellis 1848), *Canton Packet* (Shearman 1849) and *Clifford Wayne* (Wady 1847; Holland 1847). No reference to pumice rafts was found.

*An Eruption in early October 1846*

There is one further account worth commenting on. On 9 October 1846 the whaler *Columbine*, Captain Stratton, encountered a pumice raft at 17°22' S and 174°27' W. On 10 October they sighted Amagura and saw the erupting volcano. Upon arrival in Vava’u they were told that several earthquakes had been felt a week before the eruption and that on the day of the eruption the trees had been covered with ash (Anon 1846a–b; for full text see Appendix 3). The reference to the earthquakes and the ashfall on Vava’u all resemble the account for the above mentioned eruption of 11 June 1846. It is possible that the volcano still displayed activity by October 1846 and that the account for Vava’u refers to the original event.

Unfortunately, the logbook of the *Columbine* does not seem to have survived.

On 20 March 1853 the whaler *Levant* of Sag Harbour passed the island, but did not note anything that would warrant a log book entry (Cooper 1855).

By 1890 the island was described as 600 feet high without any reference to vegetation, while Toku was described as ‘wooded’ (British Admiralty 1896).

*Later events*

Intermittent fumarolic activity was noted for June 1863. The log of the New Bedford whaler *Plover* notes that the island was seen on 10 and 11 June 1863. For the latter date the entry states

‘Amagura still in sight, bearing SSE; distance 20 miles. Today we saw smoke on the island.” (Macy 1864).

As the island was uninhabited, and from that distance, it can only infer volcanic activity.

When visited by H.M.S. Penguin in November, 1898, discoloured water was noted northward and north-eastward of the island.

In June, 1939, the island was showing 'considerable' volcanic activity, with steam continually issuing from the summit and a column of yellow and brown smoke emitted at 10minute intervals.
Conclusions

The review of the historic evidence for the 1846-47 eruptions showed that a major eruption occurred on 9 June 1846 with destruction of part of the crater. A major ash cloud was emitted, projecting above the trade winds. A minor eruption was noted in October 1846. It is possible that other smaller eruptions occurred during that and subsequent years that went by unnoticed.
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<thead>
<tr>
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<td>Lava flows</td>
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<td>Lava Volume: 5.5 ± 5.0 x 10^7 m³</td>
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<tr>
<td>Tephra Volume: 5.5 ± 5.0 x 10^8 m³</td>
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<tr>
<td>Area of Activity: Summit, west and SE sides</td>
<td>Flank (excentric) vent</td>
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<td>Area of Activity: North-central part of the island</td>
<td>Explosive eruption</td>
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<td>Lava flow(s)</td>
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<td>Phreatic explosion(s) (?)</td>
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<tr>
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<td>Fumarolic activity</td>
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Bibliography


British Admiralty (1889) Search for dangers in the South Pacific between New Zealand and the Tonga Islands 1888. London: Hydrographic Department, Admiralty.


Davenport, John (1849) Logbook kept on board the schooner Alfred of New Bedford . From 28 August 1845 to 1849. Pacific Manuscripts Bureau, New England Microfilm Project, Microfilm n° 801.

[Ellis 1848] Logbook kept on board the ship Kingston of Fairhaven, Captain Ellis, master. From 14 September 1844 to 28 April 1848. Pacific Manuscripts Bureau, New England Microfilm Project, Microfilm n°342.

Erskine, John Elphingstone (1853) Journal of a cruise among the islands of the Western Pacific, including the Feejeees and others inhabited by the Polynesian Negro races, in her Majesty's Ship Havannah. London; John Murray.
Findlay, Alexander George (1863) *A directory for the navigation of the South Pacific Ocean: with descriptions of its coasts, islands, etc., from the Strait of Magalhaens to Panama, and those of New Zealand, Australia, etc.: its winds, currents and passages by Alex. Geo. Findlay*. London: Published for Richard Holmes Laurie.

Findlay, Alexander George (1871) *A directory for the navigation of the South Pacific Ocean: with descriptions of its coasts, islands, etc., from the Strait of Magalhaens to Panama, and those of New Zealand, Australia, etc., its winds, currents and passages by Alexander G. Findlay*. London: Laurie.

Findlay, Alexander George (1874) *A directory for the navigation of the South Pacific Ocean: with descriptions of its coasts, islands, etc., from the Strait of Magalhaens to Panama, and those of New Zealand, Australia, etc., its winds, currents and passages by Alexander G. Findlay*. 3rd ed. with additions to 1874. London: Laurie.

Findlay, Alexander George (1877) *A directory for the navigations of the Pacific Ocean: with description of its coasts, islands, etc., from the Strait of Magalhaens to the Arctic Sea, and those of Asia and Australia: its winds, currents and other phenomena by Alexander G. Findlay*. London: Laurie.


Gibbs, H.S. (1972) *Soil map of Tongatapu Island, Tonga. Scale 1:100.000. NZ Soil Bureau Map 81*. Wellington: NZ Soil Bureau, DSIR.


La Perouse, Jean-Francois de Galaup (1798) *A voyage round the world: which was peformed [sic] in the years 1785, 1786, 1787, and 1788, by M. de La Peyrouse: abridged from the original French journal of M. de La Peyrouse, ... To which are added: a voyage from Manilla to California. By Don Antonio Maurelle: and an abstract of the voyage and discoveries of the late Captain G. Vancouver. Edinburgh: printed by J. Moir; for T. Brown*.

La Perouse, Jean-Francois de Galaup (1799) *A voyage round the world: performed in the years 1785, 1786, 1787, and 1788, by the Boussole and Astrolabe, under the command of J.F.G. de La Perouse published by order of the National Assembly, under the superintendence of L.A. Milet-Mureau ... London: Printed by A. Hamilton, for G.G. and J. Robinson ... [etc], 1799*.

La Perouse, Jean-Francois de Galaup (1807) *A voyage round the world performed in the years 1785, 1786, 1787 and 1788 by the Boussole and Astrolabe, under the command of J.F.G. de La Perouse published by order of the National Assembly under the superintendence of L.A. Milet-Mureau; translated from the French. London: Printed for Lackington, Allen, and Co., 1807*.


Langdon, P. (1979) *Their she went: An interim Index to the Pacific Ports and islands visited by American whalers and traders in the 19th century being a supplement to 'American Whalers' in the Pacific, A guide to records and microfilm.* Canberra: ANU.

Langdon, P. (1984) *Where the Whalers went. An index to the Pacific Ports and islands visited by American Whalers (and some other ships) in the 19th century* Canberra; ANU.

Lawry, Walter (1850) *Friendly and Fiji Islands. A missionary visit to various stations in the South Seas in the year 1847.* London: J. Mason.

**Lewis 1985**

Lewis, J. 1978 *Mitigation and preparedness for natural disaster in the Kingdom of Tonga.* London: Ministry for Overseas Development.


Macy, George N. (1864) Logbook kept on board the barque *Plover* of New Bedford, Captain George N Macy, master. From 16 October 1862 to 8 August 1864. Pacific Manuscripts Bureau, New England Microfilm Project, Microfilm n°888


Maurelle, Don Antonio (1798) . A voyage from Manilla to California in: Jean-Francois de Galaup La Perouse, A voyage round the world: which was peformed [sic] in the years 1785, 1786, 1787, and 1788, by M. de La Peyrouse: abridged from the original French journal of M. de La Peyrouse, ... To which are added: A voyage from Manilla to California. By Don Antonio Maurelle: and an abstract of the voyage and discoveries of the late Captain G. Vancouver. Edinburgh : printed by J. Moir; for T. Brown.

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UNEP (1988) http://www.unep.ch/islands/IKY.htm#1254


Appendix 1:—Full Text from the Samoan Reporter

The following is the full text of:
Mills, William (1847) Volcanic eruption at the Vava'u Islands. The Samoan Reporter nº 5, March 1847, p. 2 cols. 2–3.

VOLCANIC ERUPTION AT THE VAVA'U ISLANDS.

The following are a few particulars relating to a new Volcanic Eruption at a small uninhabited Island, belonging to the Vavau groupe. Toku is the proper name, but known on the Charts as Amagura. They have been furnished principally by J. C. Williams Esq. U. S. Consul, and Cap. Samson, Ship Charles W. Morgan.

The Island of Toku lies about 60 miles in a N. W. direction from Vava'u. It is of Volcanic formation, but there is no recorded eruption for a very long period.

On Tuesday the 9th of June, and two following days, severe shocks of Earthquakes were felt at Vava'u, during every 15 or 20 minutes. They could be easily perceived on board the vessel lying at anchor in the harbour. On the night of the 11th bright flashes of light were perceived in the direction of Toku, reflected against the heavens, but at a very high angle.

On the morning of the 12th every thing was covered with a thin dust, the trees and grass presenting a strange appearance. The Samoan natives who were with Mr. Williams, remarked, that the dew in that country was somewhat different from that at their own Island! A strong suffocating smell of sulphur was perceived.

Mr. Williams left Vava'u on the 13th the Island of Toku lying nearly in their course. As they approached it, they could perceive immense volumes of smoke and dust ascending, as they came still nearer to it, they could form some idea of the immense extent of the crater, which is described as being of very great diameter.

The most interesting fact connected with this Eruption, is, the very great distance to which the ashes were carried, and in a direction contrary to what might be expected during the regular N. E. trades. About 2 o'clock, on the morning of the 12th, and at least 3 degrees in a N. E. direction from Toku, Captain Samson of the "Charles W. Morgan," when on his way from Eooa, one of the Tonga Islands, to this groupe [Samoa, Ed.] entered a shower of ashes. At the time, it was blowing a double reefed topsail breeze from the N. East, but it was a beautiful clear star light night.

Before they entered, it appeared like a squall, so soon as they got into it, the eyes of the men on watch were filled, and the deck began to be covered with the fine dust. Captain Samson put the ship about, but being persuaded that there was no land near, he continued his course.
So soon as the sun arose, the dust appeared of a dark red colour, rolling over like great volumes of smoke, presenting an awful appearance; at 8 o'clock it was so dark that candles had to be lighted in the cabin; at 11 a.m. it began to clear a little, the sun appearing occasionally. By noon they had got out of it, being then in 171° 45 W. and 11° 2 S. having sailed across the shower at least 40 miles. Captain Cash of the Ship “Massachusetts” got into the shower about the same time, though at least 60 miles to the East of Captain Samson, and not far from Savage Island.

The ashes penetrated every crevice of the ship, and fell in such quantities, that Captain Samson believes tons fell on the deck, which had to be cleared from time to time.

The question is, how could such a shower be carried so far, right in the teeth of the prevailing winds? It can only be explained I think, by supposing, that the ashes had been thrown at once with great force, and to a very great height, into a upper current of air, and after' being borne several degrees to the east, then fallen into the under stratum, and so carried back again towards the Island from whence they came.

The dust is of a dark gray slatey colour. Of specific gravity 1.076. containing a large proportion of Sulphur, and so much of free Sulphuric acid as to give it a sharp taste. It also contains a small proportion of iron. No doubt a minute analysis would give the usual combinations of Silica, and several of the Sulphates usually found in Volcanic dust.

Wm. MILLS.
Appendix 2:—Noon-time Positions of the three whalers

Given below are the noon time positions of the whalers Charles W. Morgan, Charles and Minerva if they fall within the area of sea bounded by 15 and 22º S and 169 and 176º W (see map). A ship’s day ran from noon-to-noon. Positions could be ‘shot’ when the sun was at its zenith. The logbook of the whalers Charles W. Morgan, Charles and Minerva all report the daily positions at the end of each entry, thus the actual days of the positions are a date ahead of the logbook date.

Table A2–1: Noon time positions and wind conditions for the whaler Charles W. Morgan

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<th>Noontime Position</th>
<th>Winds</th>
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<td>3 June</td>
<td>off 'Eu, Tonga</td>
<td>SE Fine</td>
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<td>4 June</td>
<td>off 'Eu, Tonga</td>
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<tr>
<td>4 June</td>
<td>5 June</td>
<td>22º56' S 174º33' W</td>
<td>EGale</td>
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<tr>
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<td>6 June</td>
<td>off 'Eu</td>
<td>NE Squalls</td>
<td></td>
<td></td>
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<tr>
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<td>7 June</td>
<td>off 'Eu</td>
<td>NE Strong</td>
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<td>8 June</td>
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<td>9 June</td>
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<td>SW squall</td>
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<td>10 June</td>
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<td></td>
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<tr>
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<td>20º30' S 172º10' W</td>
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<td>12 June</td>
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<td>14 June</td>
<td>17º22' S 171º20' W</td>
<td>ESE</td>
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<td>23 June</td>
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</tbody>
</table>
Figure 7 Noon time positions of the whalers Charles, Charles W. Morgan and Minerva
Appendix 3:—Newspaper report of October 1846

The following is the full text of:

VOLCANIC ERUPTION AT THE FRIENDLY ISLANDS

Capt. Stratton, of the Columbine, arrived at Sydney, states that, on the 9th of October, in lat. 17 deg. 22 min. S., Ion. 17 deg. 4 min. 27 sec. fell in with a great quantity of pumice stone. On the 10th, made the island of Amargura, Friendly Islands, saw the volcano in full play, throwing up an abundance of smoke and stone. The fire was not perceptible during the day, but at night the effect was awfully grand. On the 11th arrived at Vavon [Vava'u Ed.], and was told that a week before the eruption took place several shocks of earthquakes were felt, and that the trees, the morning after the eruption, were covered with sulphur.
Appendix 4:—Newspaper report of June 1847

The following is the full text of:

VOLCANIC ERUPTION IN THE PACIFIC

A new volcanic eruption has occurred upon a small uninhabited island belonging to the Tavau [Vava'u Ed.] group of which an account has been published at Samoa, by J. C. Williams Esq., U.S. Consul, and Capt. Sampson of New Bedford. The island is named Toku, and is 60 miles N.W. from Tavau. On the 9th of June severe shocks of an earthquake were felt at intervals; at Tavau, on the night of the 11th, a very bright light was seen in the direction of Toku. The next morning everything was covered with dust and the air had the smell of sulphur. On the 13th, Mr. Williams left Tavau and approached Toku. Immense volumes of smoke and dust were perceived, and on the morning of the 12th, Capt. Sampson, of the C.W. Morgan, whaler, on his way from one of the Tonga Islands, entered the shower of ashes. Capt. Cash of the ship Massachusetts, got into the shower about the same time, though at least 60 miles east of Capt. Sampson, and not far from Savage Island. The ashes penetrated every crevice of the ship, and fill in such quantities that Capt. Sampson believes tons fell on deck, which had to be cleared from time to time.