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GIFTS FROM THE WAVES

A case of marine transport of obsidian to Nadikdik Atoll and the occurrence of other drift materials in the Marshall Islands

by
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Preface

The oceanic dispersal of plants and animals has been the focus of some studies ever since organised natural history started in the Pacific, and the dispersal by sea rafting has been given due consideration. The find of drift materials is a common occurrence on the Pacific Islands, but in most cases the origin of the material is equivocal. Thus while the principle is known and documented at length, there is a need to document those occasions where positive proof of origin can be furnished.

This document discusses a piece of pumice with a chunk of obsidian attached found on Nadikdik Atoll in the southern Marshall Islands, and places it into the context of other drift material

Acknowledgments

While the fieldwork data were collected between 1990 and 1992, the bulk of the report was written after the author's tenure as the Republic of the Marshall Islands Deputy HPO had ended and the author had taken up a lectureship at Charles Sturt University, Albury, NSW.

I am indebted to Dr. Steve Simon, Republic of the Marshall Islands Independent Nationwide Radiological Survey for support in conducting the fieldwork. Part of the fieldwork leading to the discovery of the obsidian-cum-pumice object described in this paper was funded by the South Pacific Cultures Fund, Canberra (Australia), the financial assistance of which gratefully acknowledged.

Finally, I am indebted to Wal Ambrose (Division of Archaeology and Natural History, RSPAS, ANU) who conducted the trace element analysis of the obsidian component.

Introduction

Many, Central Pacific island cultures of Micronesia and Polynesia do not have access to sharp stone implements for want of stone raw material which can be easily flaked, such as silex, chert or obsidian. The geological nature of the islands, mainly coral reefs and raised limestone islands precludes the occurrence of such material. Where present, igneous rock such as basalt was exploited for adze manufacture, but again, the material was not suitable for small artefacts. It is little wonder then that flakeable materials were traded over large distances. Obsidian, a volcanic glass, is such a material. Because it is the most homogeneous, obsidian is the most flakeable of all materials available to Pacific Island populations short of using totally homogenous artificial glass, such as bottle glass.

The Lapita culture has attained world fame for its long distance trade of obsidian. Flakes of obsidian sourced to their original outcrops largely in the Bismarck Archipelago off New Guinea have frequently been used as evidence of long-distance transport of items and ideas. In some instances obsidian outcrops could be identified 2000 km away from the archaeological sites in island Melanesia where the flakes were found (see Allen 1984; Allen & Bell 1988; Ambrose 1976; 1978; Ambrose & Green 1972; Ambrose *et al*. 1981; Bird *et al*. 1981; Green 1978; 1979; 1982; Kirch 1988a; 1988b; Poulsen 1987; Smith 1974; Smith *et al*. 1977; Spriggs 1984). In addition, some Talasea obsidian has been found on Sabah in Borneo, some 2000 km to the northwest (Bellwood & Koon 1989). It has been argued in all cases that the obsidian has been traded. In the conceptual framework archaeologists have always assumed that since obsidian is heavier than water it does not float and *eo ipso* had to be transported by people to their destination.

This brief report discusses a rather large piece of obsidian attached to an even larger piece of pumice, which at one point in the past drifted into the waters of the Marshall Islands and was deposited on an island of Nadikdik Atoll. The finding that there is an option how obsidian can actually float is bound to shatter this innocent assumption that all obsidian had to be sourced by people. The increasing number of raw material sourcing studies in the Pacific archaeologist tends to gloss over the fact that accidental transport is in fact possible. Drift-wood is a common occurrence on many islands. This report shall not argue a case of accidental transport over intentional transport, but shall act as a cautionary tale. The paper also summarises the data available on extraneous materials encountered on the atolls of the Republic of the Marshall Islands and their implications.

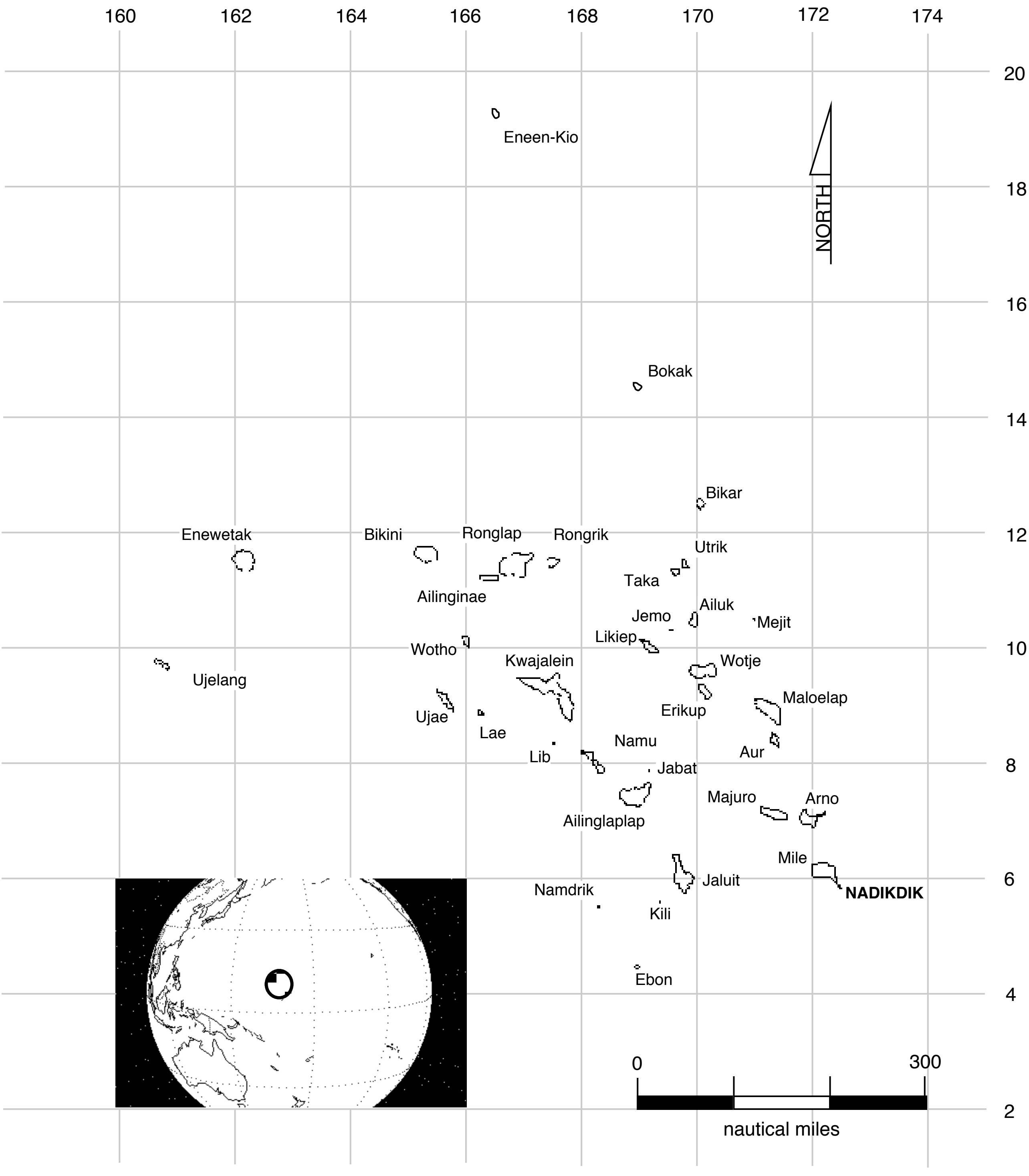

Figure 1. Map of the Marshall Islands, showing the location of Nadikdik Atoll.

Before we look at the piece of pumice and obsidian itself, let us briefly look at the geography and geological make-up of the atolls making up of the Marshall Islands.

Geography and Geology

The Marshall Islands (*Aelon Kein Ad),* comprising 29 atolls and 5 islands, are located in the north-west equatorial Pacific, about 3790km west of Honolulu, about 2700km north of Fiji and 1500km east of Ponape. With the exception of the two northwestern atolls, Enewetak and Ujelang, the Marshall Islands are arranged in two island chains running roughly NNW to SSE: the western Ralik Chain and the eastern Ratak Chain (figure 1). Majuro Atoll, with its close neighbour, Arno Atoll, is located on the northern margin of the southern group of atolls of the Ratak Chain (or *Ratak-rak*). Not counting the five islands, Jemo, Jabwat, Kili, Lib and Mejit, the atolls of the Marshall Islands range from very small, with less than 3.5km^2, such as Nadikdik (Knox) Atoll to very large. With 2,173km^2 lagoonal area, Kwajalein Atoll has the distinction to be the atoll with the World's largest lagoon.

The Marshall Islands consist of atolls and raised islands. In his initial classification of atoll formation, Charles Darwin distinguished between three stages: Fringing reef, barrier reef and atoll. In the substantially more detailed typology of atoll development drawn up by Tayama (1952, quoted after Thomas 1967), eight forms of reefs can be distinguished, ranging in development from apron reefs to table reefs. Following Darwin's subsidence theory, the atolls of the Marshall Islands were initially formed as apron reefs and fringing reefs around volcanic islands, similar to Ponape; increased subsidence of the volcanic cone and ongoing reef growth led to the development of almost barrier reefs or barrier reefs, such as Palau; Final subsidence led to the development of almost atolls, such as Chuuk Lagoon. Darwin's subsidence theory could be proven right during the deep-drilling experiments undertaken on Enewetak Atoll in conjunction with the nuclear testing programme. While the earlier cores drilled on Bikini still encountered a limestone formation at 775 metres (Ladd *et al.* 1948), while the two cores drilled at Enewetak encountered a volcanic base at 1271 and 1405 metres respectively (Emery *et al.* 1954; Tracey & Ladd 1974).

The atolls of the Marshall Islands are aligned along two chains, Ralik and Ratak. Bathometric maps show that there is also an abundance of seamounts (guyots), some of which reach almost to the surface, such as Keats Bank east of Arno Atoll. Most of these guyots are aligned along the same axes as the Ralik and Ratak Chains, so that these bathometric features as a whole have recently been termed Ralik Ridge and Ratak Ridge (see Hein *et al.* 1988, p. 256). The reefs in the Marshall Islands consist of fully developed *atolls*, such as Majuro, *almost table reefs*, such as Wake/Eneen-Kio, and *table reefs*, such as Mejit (see Menard 1986, p. 36; 186 ff.; Scott & Rotondo 1983).

Coral growth, and correspondingly reef width, is most vigorous in areas in the general direction of prevailing winds, currents and waves. Since the Marshall Islands are in the zone of the northeastern tradewinds, with predominant wind and swell direction from the southeast, the zone of most reef growth is the southern and eastern side. Conversely, deep passes through the reef platform occur most frequently on the leeward side of the atolls. Thus on most atolls there are several passes, which are located in the west and northwest of the atoll. The islets and islands making up the supra-tidal area of the atolls comprise of unconsolidated sediment with the exception of the islet's fringe where beachrock can have formed at the freshwater lens discharge zone.

At no point in the Republic of the Marshall Islands is volcanic or sedimentary rock other than limestone or beachrock (=cemented sand) accessible at the surface. In addition, no sources of obsidian or other flakeable material exist on the islands of the Marshallese atolls. Thus the occurrence of any volcanic material is of substantial interest to the academic community.

The Pumice-cum-Obsidian

This section describes the piece of pumice-cum-obsidian under discussion. The item under scrutiny is a large piece of pumice with a slab of obsidian attached to one side (figure 2). Stone (1933) uses the following terminology for ejecta: Boulders or blocks (≥256mm); Cobbles (64-256mm); Pebbles (4-64mm); Lapilli (2-4mm); and Ash (≤2mm). Based on this terminology the piece of pumice encountered would be classified as a *boulder*.

The piece is of oblong-rounded shaped with rounded and worn edges of the pumice and a flattish, smooth bottom at the obsidian side. The pumice side shows some flaking, with worn edges, suggesting that the flaking occurred early on and that subsequent erosion took place. The obsidian section consists of a continuous slab with a one major groove running to a depth of approximately one third of the thickness of the obsidian. The piece shows no marine growth in form of barnacles, algae or other depositions, suggesting that the piece was suspended in seawater only for a comparatively short time. The piece showed some fungal growth at the pumice surface, consistent with the fungal and algal growth encountered on coral boulders and rubble which had rested in shaded supra-tidal localities for some time.

The pumice is of dark grey to blackish colour and medium to coarse grained, with air cavities ranging in size from 0.5mm to 15mm. On the whole it is dense and compact. Compared to other pumice seen in the Marshalls, this piece belongs to the hard type, suitable for woodworking, but too hard ('sharp') to be used for personal hygiene. The piece of a irregular shape and hence irregular dimensions. It measures about 32 cm in length, 22 cm in width and 20 cm in thickness. The slice of obsidian is about 22cm long, 5cm wide and 4-5cm thick. About 3.5 cm of this thickness would yield high quality obsidian suitable for flaking.

The piece of pumice-cum-obsidian under discussion was found in June 1991 during an archaeological reconnaissance survey of Nadikdik Atoll, south of Mile Atoll. It was found with the side bearing the obsidian resting on the ground. If suspended in water, that side, too, would point downwards. It is clear from its position in relation to the shoreline, that it floated inland and that it had been deposited there by wave action. Given the position it rested, the presence of obsidian would not have been noticed, had not the extra-ordinarily large size of the pumice attracted the author's attention. Once discovered other larger pieces of pumice found in the vicinity were also scrutinised for the occurrence of obsidian, but none was noted.

Figure 2. Photographs showing the piece of pumice-cum-obsidian found on Nadikdik Atoll.

Dating the deposition of the piece of pumice on Nadikdik Atoll is complicated. It can only be provided in kind of a *terminus post quem*.

In the following section the geography of the island and the historical data available to us will be reviewed. As will be shown, the island was ravaged by a typhoon in 1905 and a deposition after that typhoon event is very likely.

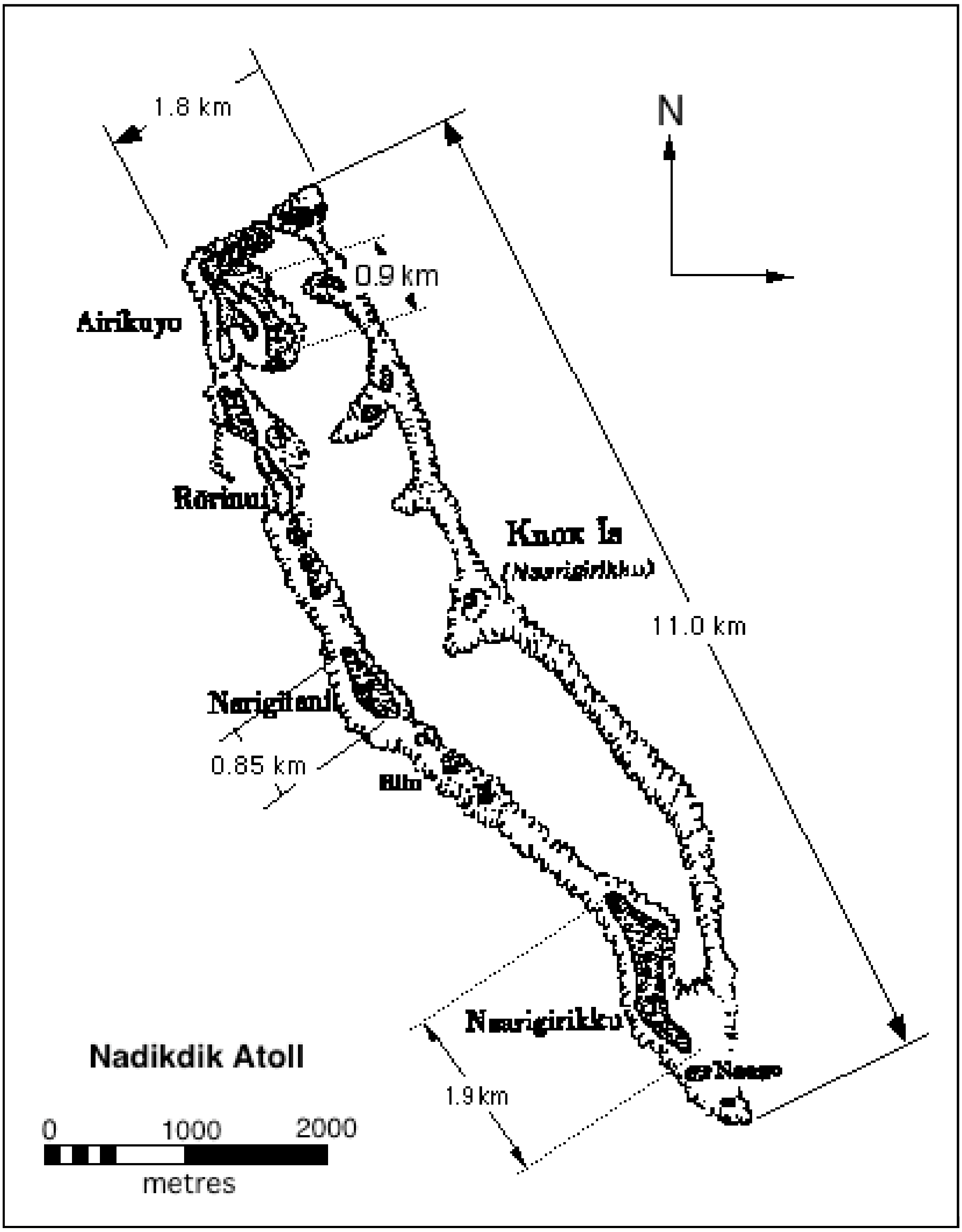

Figure 3. Map of Nadikdik Atoll showing the overall length of the major islets.(after: USHO Chart 6003, North Pacific Ocean, Marshall Islands, Mile Atoll (Northeastern Part), Original scale 1:36,640. Original drawn up September 1944; map with additions by the author).

Nadikdik Atoll

Nadikdik Atoll, in the literature also known as "Knox Atoll", forms the southernmost atoll in the (eastern) Ratak Chain and is located at 5°45' North and 172°10' East. The atoll comprises 18 islets and sand cays with a combined land area of only 0.98 km^2 which makes it the 27^{th} largest atoll in the Marshall Islands (of 33; not counting Eneen-Kio), enclosing a lagoon area of 3.42 km^2 (29^{th} largest lagoon). The atoll is located off the southeastern tip of Mile Atoll, separated from the latter by "Klee Passage", a 3 nm wide strait. Nadikdik and Mile are supported by the same submarine mountain and are connected at the 60 –70 foot isobath.

Nadikdik Atoll is covered on sheets "8639 IV NE Chirubon NE" and "8639 IV SE Chirubon SE" which are part of a series of maps drawn up by the U.S. Army Map Service in 1946 (Map AMS Series W861 Scale 1:25,000)., which wased on U.S. Navy aerial photography flown in 1944 (same map also issued in 1947).. The atoll comprises of a series of small islands on the western reef platform with a cluster of islets in the north and a larger island (Nadikdik) in the south and the islet of Nariktal in the centre. On the eastern, 'weatherward' reef platform there are only a few scattered islets, too small and too exposed and thus unfit for permanent human habitation (figure 3). The northern part of the atoll with the island where the pumice was found is reproduced in detail in figure 4. The ocean side of the small northwestern islets showed a well-defined storm beach with coral rubble sorting even at the leeward shore (figure 5) and a succession of accretion ridges demarcated by washed-up coconuts in various states of germination and growth (figure 6) consolidating the gained land. On the island of Aelon-eo a number of successive beach ridges can be followed into the interior of the island (figures 7 & 8) showing that this process has been occurring for some time.

Description of Nadikdik

Nadikdik Atoll is one of the few atolls of the Marshall Islands which does not possess a passage through the reef. Access is only possible by boat through the surf on the leeward side (which was the method chosen by the survey) or by passing at high tide over the reef into the lagoon. The lagoon is very small and was found to be very shallow. Large patches of the lagoonal bottom fall dry at low tide (figure 9).

Table 1. Islands of Nadikdik Atoll (after Bryan 1971; Hager 1886; Krämer & Nevermann 1938,; Witt 1881; and other sources).

Nº	English name	Marshallese name	Japanese name	Other names	sq miles
1	unnamed islet on eastern reef platform				≤0.001
2	unnamed islet on eastern reef platform				≤0.001
3	unnamed islet on eastern reef platform				≤0.001
4	unnamed islet on eastern reef platform				≤0.001
5	unnamed islet on eastern reef platform				≤0.001
6	unnamed islet on eastern reef platform				≤0.001
7	unnamed islet on eastern reef platform				≤0.001
8	unnamed islet on eastern reef platform				≤0.001
9	unnamed islet on eastern reef platform				≤0.001
10	unnamed islet on eastern reef platform				≤0.001
11	unnamed islet on eastern reef platform				≤0.001
12	unnamed islet on eastern reef platform				≤0.001
13	unnamed islet on eastern reef platform				≤0.001
14	unnamed islet on eastern reef platform				≤0.001
15	unnamed islet on eastern reef platform				≤0.001
16	unnamed islet on eastern reef platform				≤0.001
17	unnamed islet on eastern reef platform				≤0.001
18	unnamed islet on eastern reef platform				≤0.001
19	unnamed islet on eastern reef platform				≤0.001
20	Nake	Nako	Naago To	—	0.007
21	Nadikdik	Nadikdik	Naarigirikku To, Narik To	Churea, Knocks Inseln, Knox Atoll, Knox Lagoon, Marshall Island, Narik Atoll, Narikerik Inseln, Narikrik Atoll, Ngadikdik, Ngarikrik, Ngarikerik	0.100
22	Didi	Didi	Riin To	—	0.004
23	Bwok	Bok-lap	—	—	0.003
24	Aneloklab	Ãne-en-loklap	—	Enilugulab	—
25	Aen	Ã-en	—	Eeng	0.032
26	Naniktal	Naniktal	Narigitani To	Nanekdal	0.062
27	Naankotkot	Naan-kõtkõt	—	—	—
28	Koabwil	Kiabõl	—	—	0.018
29	Lolimwe	Lãlimwa	Rorinui To	—	0.020
30	Aelingeo	Aelõñ-eo	Airikuyo To, Airiku	Alingio	0.600
31	Alenkan	Aelõñ-kan	—	—	—
32	Ilenlkan	Ileel-kan	—	—	—
33	Nanmao	Na-meej	—	—	0.075
34	Mwonaken	Nõñ-ak-en	—	—	—

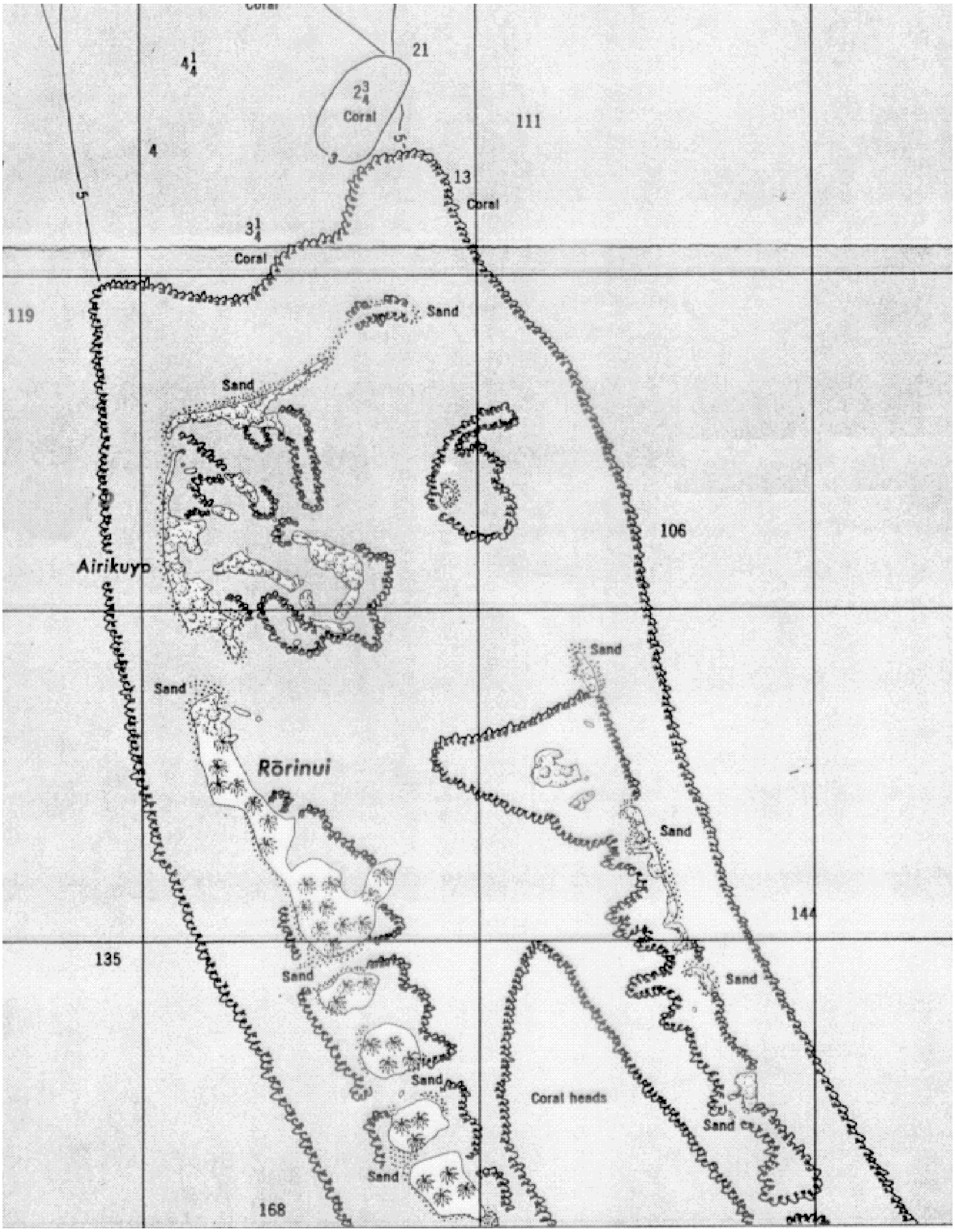

Figure 4. Enlarged section of the northern part of Nadikdik Atoll (after: AMS 1946a), Original scale 1:25,000. The grid is set out in 1km squares.

Figure 5. The western, leeward shore of Nadikdik Atoll.

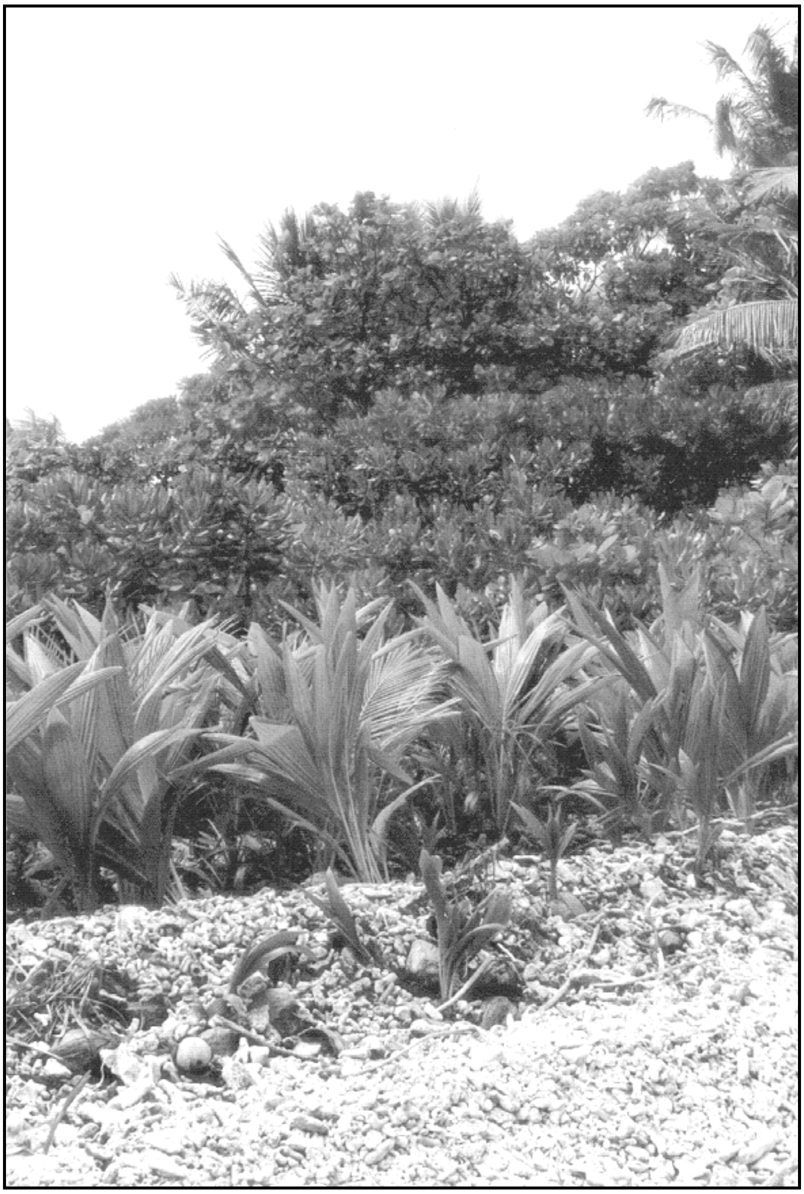

Figure 6. Storm beach at Nadikdik showing the deposition of floated coconuts in two stages of germination/growth, as well as a few not yet germinated nuts in front.,

This is especially true for the northern part of the atoll, which has a number of small mangrove patches and evidence of new and ongoing colonisation. Worth noting are also the large *Porites* sp. microatolls, likewise located in the northern part of the atoll.

The configuration of the atoll is such that the shallow lagoon lacks a pass and the wave action on the reef so strong that it does not permit the entry of a vessel other than a flat-bottomed launch at high tide (and from the protected western shore). Thus all ships normally hove to at the leeward shore while people are ashore. Even on quiet days the atoll experiences a surf (figure 10), and landing on the atoll is not always possible.

The survey of Mile and Nadikdik Atolls was conducted in conjunction with the Independent Nationwide Radiological Survey in June 1991. All islands on Nadikdik Atoll, with the exception of Nadikdik itself, were found to be uninhabited. On the latter a single household was encountered which had been established comparatively recently.

Figure 7. Island of Aelon-eo, Nadikdik Atoll. Photograph showing the ground cover which is very similar to that of Aelon-kan. Note the beach accretion ridges.

Figure 8. Island of Aelon-eo, Nadikdik Atoll. Photograph showing the ground cover which is very similar to that of Aelon-kan. Note the beach accretion ridges.

Figure 9. Panoramic view of the lagoon of Nadikdik Atoll at low tide, looking east. (Photo taken from Aelon-eo). The small islets in the background delineated the eastern fringe of the reef platform. Note the scatter of coral boulders and rubble on the sandy bottom, indicative of storm deposits and continued high energy wave action washing across the eastern reef platform

Figure 10. The leeward shore of Nadikdik showing the shingle beach and a vessel hoving to.

Like the others, the island of ***Aelon-kan***, a small island northeast of Aelon-eo, was surveyed on foot. No archaeological or historical sites were found. This is in keeping with the environmental destruction wrought by the 1905 typhoon. Unless systematic coring or testing has been carried out it cannot even be deemed certain that any of the sediment layers predate the typhoon. The vegetation encountered on the island of Aelon-kan comprised of a coastal broadleaf forest with a fringe of coconut (*Cocos nucifera*). The majority of the vegetation was largely made up from *Scaevola taccada*, and some coconuts (*Cocos nucifera)* as well as *Guettardia speciosa*. In addition some *Morinda citrifolia*, *Pemphis* sp., and *Luminitzera littorea* were encountered. The ground cover was sparse, with *Polypodium scolopendria*, sprouted *Cocos nucifera*, and *Nephrolepsis* sp. predominant.

Animals seen on Aelon-kan during the 1991 survey were the blue-tailed skink (*Emoia cyanura*), a small lengthwise-banded skink (*Emoia arnoensis* ?) and large tree geckos (*Gehyra oceanica*). Especially abundant were large red land crabs and hermit crabs. Some chewed fallen coconuts gave evidence for the presence of rats, although none were seen to furnish positive identification as to species.

At the time of the survey the lagoon was populated with a large number of small (0.3 to 0.7m long) black-tipped reef sharks (*Carcharhinus melanopterus*) which were very curious and followed people walking on the lagoonal beach.

The only non-floatable artefacts found during the archaeological survey of the western islands of Nadikdik Atoll were aerial bombs (figure 11), either Japanese practice bombs or they may have been dropped in an attack on the atoll of Mile, which had been a major Japanese military base during the war (cf. Spennemann 1991; USSBS 1947).

During the survey a great deal of drift material ranging from large driftwood trees and cut driftwood logs to fishing net floats of all kinds and sizes, as well as glass and plastic bottles, and fluorescent light tubes were encountered along the shores. Although they were concentrated in a zone reaching about 5-10m from the high tide mark of both lagoonal and ocean shores, individual pieces could be encountered up to 20-30m inland. In the main inland deposition zone also numerous pieces of pumice were seen, one of which was rather large and stood out from the others because it had a large piece of obsidian attached to it.

Figure 11. Remains of aerial bombs found near Aelon-eo, Nadikdik Atoll. These bombs date to World War II.

Overview of Nadikdik's History

Because Nadikdik was uninhabited for the most part of this century (see below), it does not figure prominently in the geographic and ethnographic literature (see PIP 1943; 1956; OPNAV 1943; JICPOA 1943; Krämer & Nevermann 1938, p. 60-61). But even for the period before 1905 only very little is known about the history of Nadikdik as it attracted little attention by Foreigners compared to neighbouring Mile.

The atoll was first seen by Europeans on June 24, 1788, when the British transport *Charlotte* under the command of Captain Thomas Gilbert and the transport *Scarborough* under the command of Captain William Marshall passed by *en route* from the newly founded British colony at Port Jackson (Australia) to Canton in China. Land was sighted at 5°58'N and 172°3' E, and a canoe with 25 people came out to make contact and trade. Gilbert (1789, p. 35-37) gives a description of the ongoings but provides no description of the atoll. The vessels then sailed north passing several other atolls of the Ratak Chain in the process. Mile was apparently initially named Gilbert Island, while Nadikdik was named Marshall Island, after the names of the Captains. This was then changed and Mile became known as "Mulgraves islands", while Nadikdik was named "Knox."

A number of British transports followed Gilbert's and Marshall's route and encountered several atolls of the Marshall Islands (Hezel 1979, p. 114-115), even though Nadikdik seems not to have been encountered again. A possible exception is the British merchant ship *Rolla*, Captain John Cummings commanding, who *en route* from Port Jackson to Canton, on 30 October 1803 encountered an island at 5°41'N 169°27"E, but could not land because of heavy surf (Hezel 1979, p. 115).

Nadikdik is also mentioned by the Russian Captain Victor S.Kromchenko, when he passed by in 1829 in the *Helena* and again in 1832 in the *America* (Hezel 1979). Again, no details on the island have been provided.

In early May 1841 the Wilkes Exploring Expedition passed through with the vessels *Peacock* (Capt. Hudson) and *Flying Fish* under the command of Captain Knox (Hezel 1979). The U.S. Exploring Expedition surveyed the atoll and provided a map, but did not land.

In the mid 1870s, the atoll is described by James Lyle Young, a trader for Adolph Capelle with the following diary entry:

> Knox Island is quite small, 1 mile in length, perhaps, without any lagoon and some 20 to 30 inhabitants landing can be effected in smooth weather on the lee side. Coconuts and Pandanus. No fresh water. (Young 1877, p. 21; entry for 14 June 1876)

This description is possibly too dire, but is the most elaborate on hand. Significantly it comes from a trader, the only mariner who would bother landing there. In addition, in December 1885 the whaler *Fleetwing* passed by (Langdon 1978; 1979), but again not much detail is known.

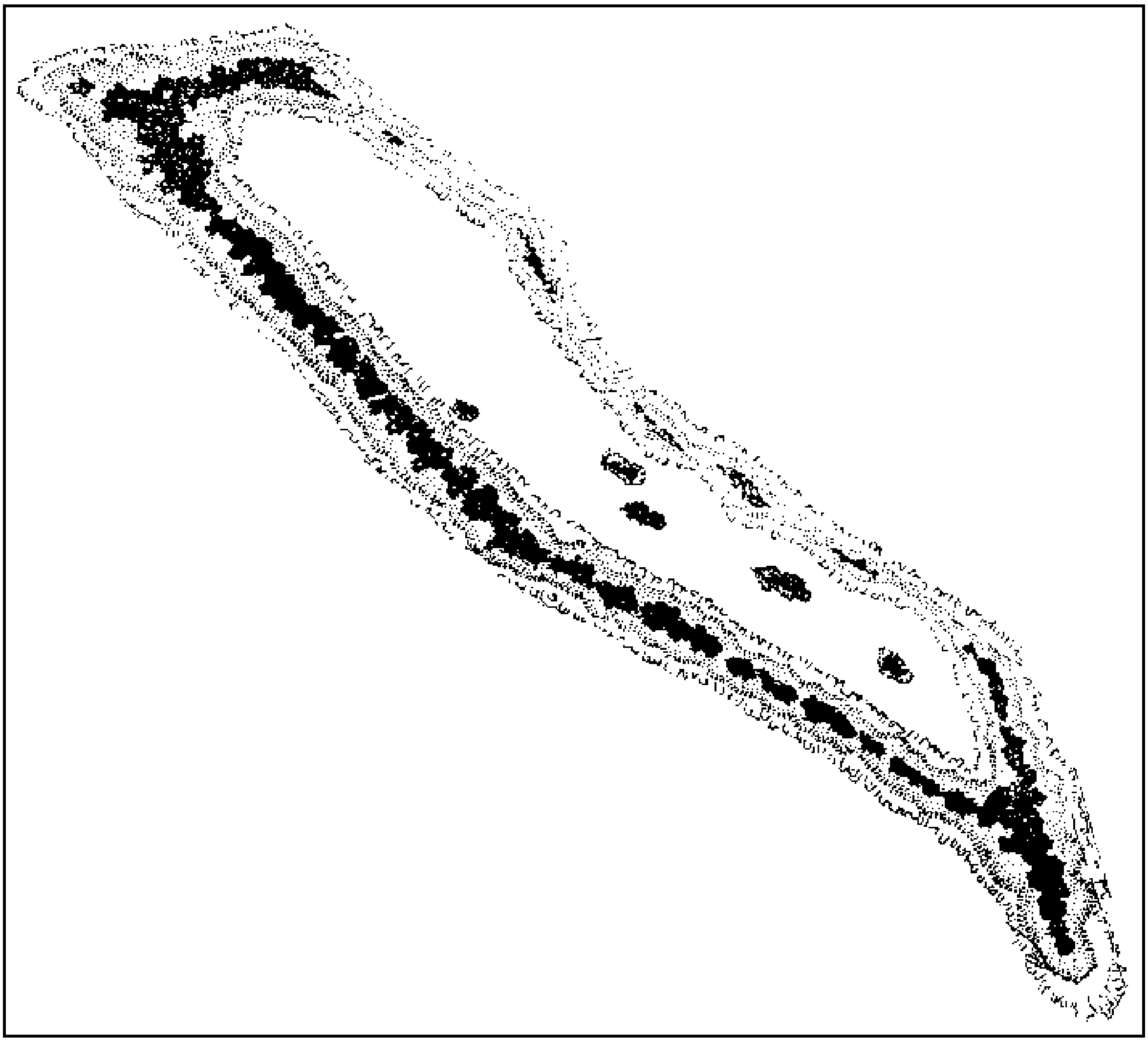

Figure 12. Map of Nadikdik Atoll as surveyed by Charles Wilkes in 1840 during the USS Exploring expedition. The map has been edited for clarity with survey base lines removed. (after Ehrenberg et al *1985).*

One *irooj* of Mile, Langerik, owns the easternmost part of Mile and the entire Nadikdik Atoll. The atoll was visited by the German gunboat *Eber* in 1888, investigating an arson attack against a European trade station on Mile, in which Langerik was alleged to have been involved. As the surf was too high to permit a landing, the *Eber* left without investigation.[1]

Nadikdik Atoll is traditionally reported as the atoll of the dead, the place where dead went and either passed on to the land of the dead in the west, or fell into a deep hole. It unclear whether this tradition is an old one, or whether it has been created as a result of the enormous toll of human life taken by the 1905 typhoon.

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1 Kommandant S.M. Kreuzer *Adler*, *Schrift über die Reise S.M. Kanonenboot* Eber *von Apia nach der Marshall Gruppe und zurück,* dated 22 November 1888. Contained in: Records of the German Admiralty, Series XII File No. PG/65070, XII.2.4.38 *Entsendung von Kriegsschiffen nach Australien und den Südseeinseln. November 1887 - Januar 1889.* National Library of Australia, Canberra, Australia. Microfilm No. M 304.—It does not sem that the Germans evenf the district administrators annual reports and trip reports mentions a visit to the atoll.

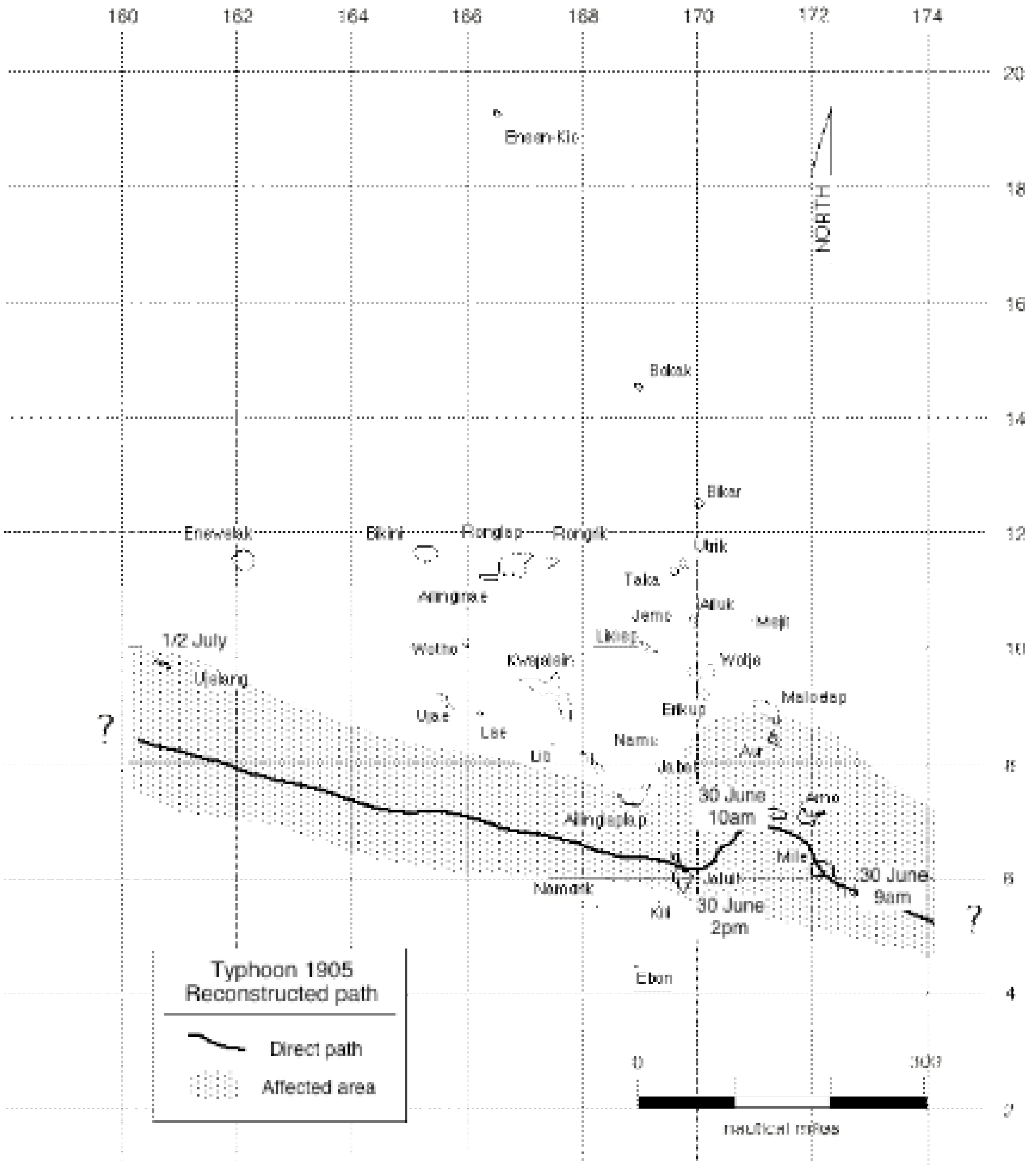

Figure 13. Tentatively reconstructed path of the cyclone of 1905. For details see text.[1]

According to Jeschke (1906) Nadikdik never had a permanent population, but was used as a seasonal fishing and copra collecting location by the people of Mile Atoll. Just before the typhoon of 1905 (see below) Nadikdik had a (temporary?) population of about 60 to 80 people. For most part of this century Nadikdik was uninhabited, but was occasionally visited by people from Mile who came and stayed on a temporary basis to exploit the copra and fish resources of the island and who caught seabirds and turtles.

1 The reconstruction shown in figure 13 is an updated and substantially modified version of a map previously published in the Cultural Resource Management Plan for Majuro Atoll (Spennemann 1990). The map is the same as that produced for the review of the German disaster management actions following the 1905 typhoon (Spennemann in press)

2 The reconstruction shown in figure 13 is an updated and substantially modified version of a map previously published in the Cultural Resource Management Plan for Majuro Atoll (Spennemann 1990). The map is the same as that produced for the review of the German disaster management actions following the 1905 typhoon (Spennemann in press)

The Typhoon of 1905

On 30 June 1905 a severe typhoon struck the Marshall and Caroline Islands. Descriptions of the cyclone and its effects are given by Jeschke (1905, 1906), Erdland (1905; 1914, p. 17); Linkens (1912) the German Authorities (Anonymous 1905; Anlagen 1907/08, 15), Krämer (1906; 1927, p. 38). A detailed analysis of this event is in progress (Spennemann in prep). On June 30th, 1905 the typhoon passed over Mile, Nadikdik (Knox) Arno, and Jaluit Atolls. Over 200 people lost their lives on that day on the affected atolls of the Marshall Islands, most of them on Nadikdik and Mile. Following the destruction of all food stocks and fruit on the trees approximately another 90 people died in the following months due to starvation. The lagoons of Mile, Ujelang and to a lesser extent of Jaluit were reported to be choc-a-bloc full of floating debris: trees, bushes, houses, broken canoes, wooden utensils and corpses (Jeschke 1905; 1906). The concentration of drift material in the waters of the Marshalls in the area between Jaluit and Ailinglaplap during July and August 1905 was so high that it constituted a serious shipping hazard, making the anyway limited relief operations not any easier (Jeschke 1906). During August and September 1905 numerous trees, house sections, broken canoes and wooden utensils drifted as for northwest as Ujelang Atoll (Jeschke 1906) and beyond. The flooding by salt water caused die back of several fruit trees as well as the contamination of the freshwater lens. Based on the information available the track of the cyclone can be sketched as shown in figure 13.

On Mile the wind set in with unusual strength at 8 am, coming from northeast. At about the same time heavy seas began washing across the islets. At about 9am gigantic waves, one larger than the other hit Mile Atoll, washed over the islands, compounded by a high tide. According to eye-witnesses, the third, and largest of these, was as high as the tops of the coconut trees. Even if we take exaggeration into account and allow for the crest of the waves to consist of wind-driven foam, a wave height of some 5-7m (16-23 feet) can be estimated. Jeschke (1905) assumes a wave-height of 12 to 15m. The strength of the wind moving through east to southeast broke by about 10:30 am and by noon blew with a strength of only 4 Beaufort from the south. The entire southern coast of Mile Atoll was affected. A small island was completely washed away and the reef platform was exposed. Some other narrow islands in the southern part of the atoll, all densely populated, were breached in many locations. Only two small spots in the southeast remained, apparently at a location where the waves had power of the waves had already been broken by Nadikdik. About 70 people died on Mile.

Worst hit during the storm was Nadikdik, which was completely washed over. Several inhabited islands were reduced to the bare reef platform and the human population of that atoll, comprising some 60-70 people, completely extinguished save for two boys who survived a 24-hour drift to Mile on a log of a breadfruit tree. According to Jeschke (1905) only occasional sandbanks with a few tree trunks survived.

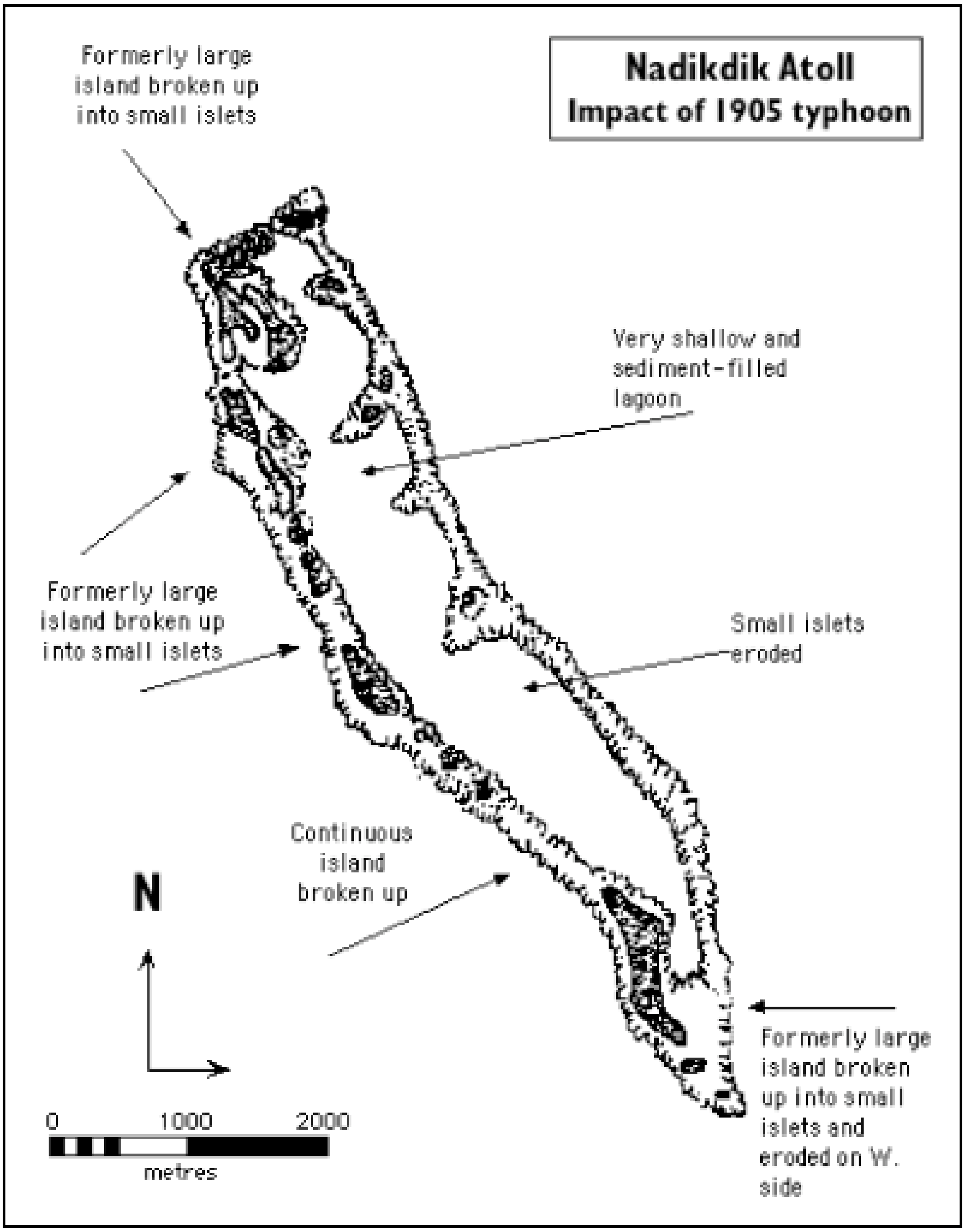

Figure 14. Map of the Nadikdik Atoll indicating the impact of the 1905 typhoon (base map: USHO Chart 6003, North Pacific Ocean, Marshall Islands, Mile Atoll (Northeastern Part., Original scale 1:36,640. Drawn up September 1944.

Wilkes's map allows up to compare the appearance of the island in 1840 (figure 12) with that in 1946 (figure 14) and thereby assess the impact of the typhoon of 1905.[1] Wilkes' map shows a near continuous island on the western side of the atoll, which is in keeping with the deposition of sand and fine gravel in this part of the Marshalls, where all the main islands of

1 Note that Wilkes map as reproduced, had been drawn up to explain the method of his "running survey" and that, therefore, the image was not checked for accurancy after it had been cut. The north arrow of the map is inverted. The image, as shown, in this report has been edited for clarity with all the survey lines, as well as other, insignificant textual information removed.

the atolls are located in the west (cf. Arno, Majuro, Mile). The island has been broken up by the typhoon-generated storm surge into a series of smaller islets with larger stretches of open reef platform. In addition, the islands at the northern and southern tip of the atoll have been broken up and substantially reduced. Over time, the islands in the north have accreted again. Likewise and islet in the centre of the eastern reef platform has been rebuilt. In its lee a large island, Nariktal, has formed on the western platform. The islands in the centre of the lagoon have been eroded. On any atoll the lagoon acts as a sediment trap for all that loose coral rubble, gravel and sand generated at the windward shore and washed across the reef platform.[1] The atoll's lagoon was small and could fill up reasonably quickly.

The impact of cyclonic surge of the 1905 typhoon on the Nadikdik settlement is a good example why the piece of pumice-cum-obsidian could not have survived the typhoon event. Cyclonic surges tend to churn up the topsoil and suspend the sediment. The floatable matter is washed off (Spennemann 1992), while the material heavier than water is eventually redeposited (cf. Spennemann 1986) and only the very heavy material remains *in situ*. The 1918 typhoon on Majuro Atoll stripped much of the narrow island of Ajeltake of its topsoil which was dumped either into the lagoon or piled up as storm ridge along the lagoonal side of the island (Spennemann in prep). A number of atolls in the Marshall islands show evidence of cyclone impacts, where all sediment has been removed from the beach platform. Examples are localities on Jaluit following typhoon *Ophelia* in 1958 (Blumenstock 1961; Fosberg 1961) and Ujelang following earlier typhoons (Fosberg 1956) and Majuro following the 1918 typhoon (Spennemann in prep.).

Thus it is unlikely that the piece of pumice on Nadikdik would have survived the typhoon *in situ*. There is abundant evidence that floatable material is refloated during annual events of sea-level higher than normal. Own observations during a 3.5 year long stay on Majuro Atoll showed that the occasional higher than normal sea-level resuspended a great amount of debris lighter than water. The pattern of rubbish disposal in the Marshall Islands was not well organised and a great amount of cans, plastic bottles and the like was discarded into the lagoon, where it floated to one of the shores downwind. Every spring high tide much of the material was refloated and found drifting in the lagoon or the open sea. Only the material deposited behind the normal MHWS mark was not affected. There were two annual exceptional high tides (in November and February), both of which resulted in much material deposited above the MHWS being refloated as well.

Based on this information then, we can assume that any floating object, such as the piece of pumice in question, would have been washed off the island of Nadikdik during any typhoon event, let alone an event of the magnitude of the 1905 typhoon. Thus the typhoon of 30 June 1905 provides a reasonably secure *terminus post quem* for the deposition of the piece of pumice.

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1 A good example to show the force of this action is the wreck of a Grumman TBD/TBF 'Avenger' aircraft that crashed in 1944 or 1945 on the oceanside of the eastern reefplatform of Majuro Atoll and today can be found in 120 feet depth at the bottom of a sediment fan in the lagoon (Spennemann 1992b).

Origin of the Piece of Pumice

Following the typhoon of 1905 the atoll was uninhabited until the mid-1980s. Today, a single household exists on the main island of Nadikdik. A transport of the piece of pumice-cum-obsidian by people into the storm deposit zone can be excluded for want of a good reason on uninhabited Aelon-kan. Thus wee need to investigate the current patterns and thereby assess possible modes of transport and the origin of the pumice.

Ocean Current Patterns in the Marshalls Area

The current patterns in the Marshall Islands are complex and material can be floating in from both east and west. Three current zones can be encountered in the Marshalls, which are (from south to north) the south equatorial current, running from east to west, the northern equatorial counter current, running from west to east, and the northern equatorial current running from east to west (see figures 15 and 16). Nadikdik Atoll is located within the north equatorial counter current (running west to east) during the northern summer, and at or near the interface between the north equatorial counter current and the northern equatorial current (running east to west) in the northern winter.

In addition, the El Niño effect changes the sea surface temperatures and hence the climatic belts. Typhoons, whose frequency seem to be running in synchrony with the frequency of the *El Niño* effect (Spennemann & Marschner 1995), bring material from other destinations to the Marshalls. Also, the current patterns as far north as the Kurushiro Current of the Japanese coast can be modified during an El Niño event (Kawabe 1985).

Nadikdik Atoll lies in the zone of the northern equatorial counter current which runs against the tradewinds. This current brings a large number of drift material to its shores (see below for details). Heavy ocean swell unhindered by any atoll or islands pounds the western and southern shore of the atoll for most of the year.

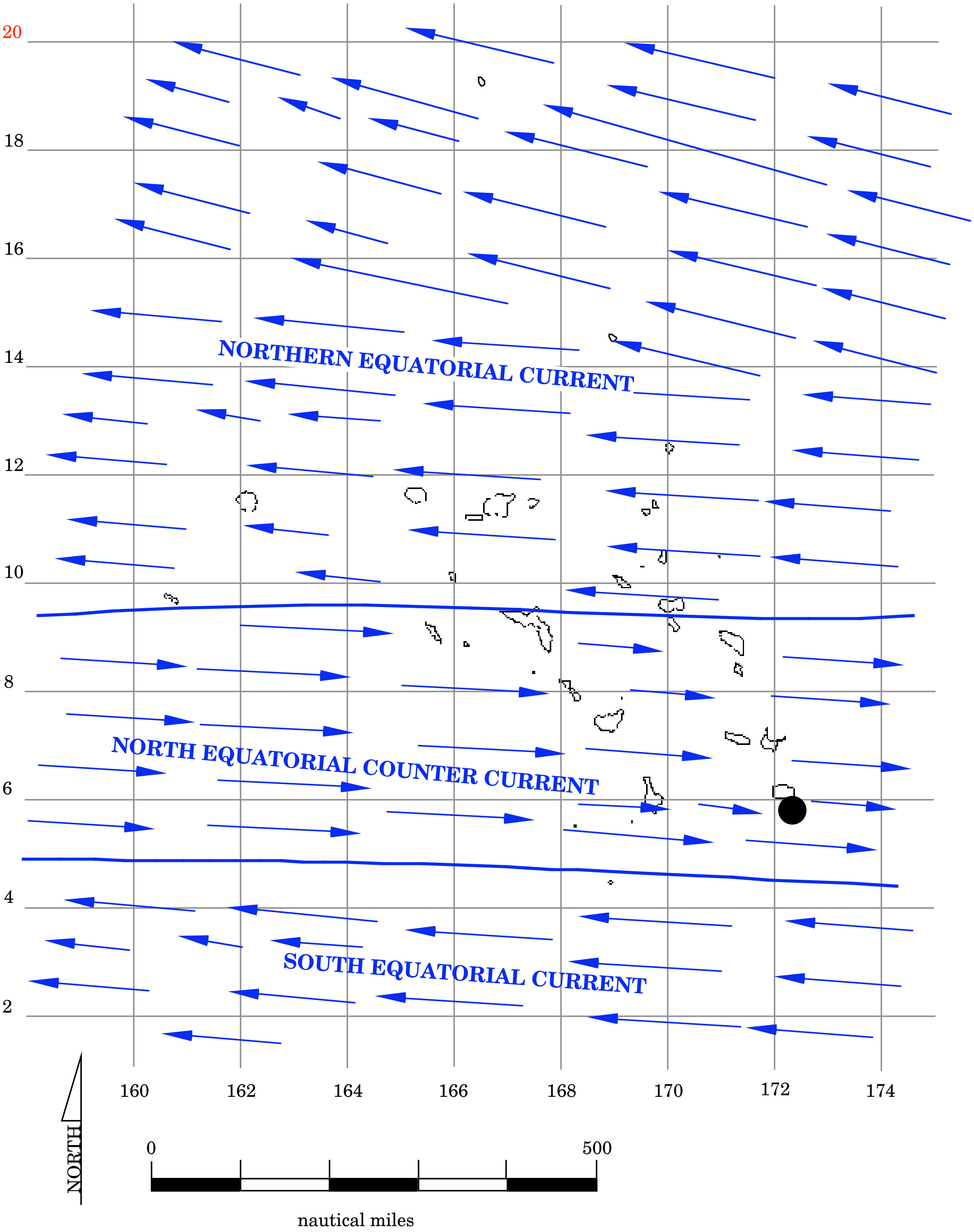

Figure 15. Current patterns in the Marshall Islands area during the northern summer. Nadikdik Atoll is highlighted.

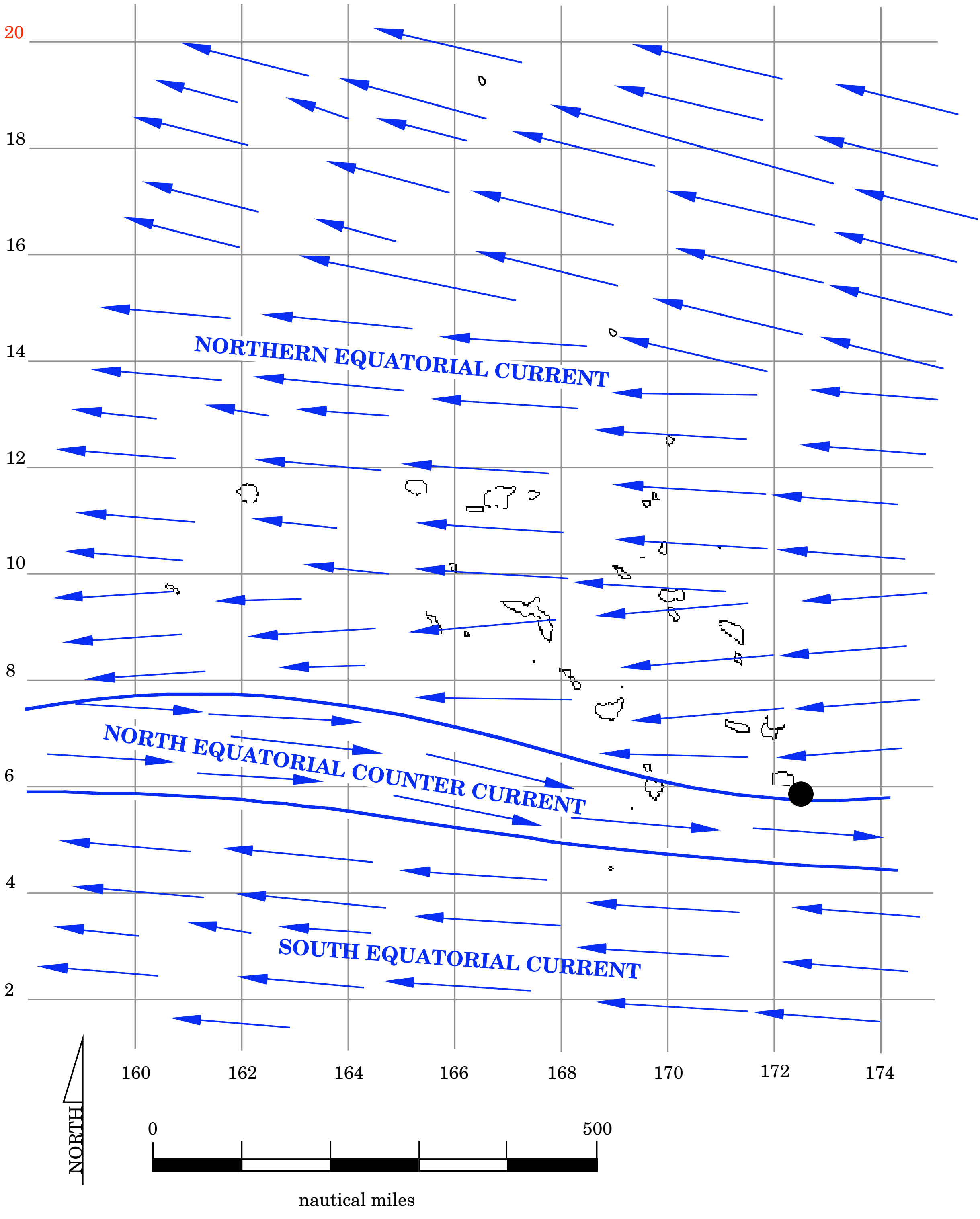

Figure 16 Current patterns in the Marshall Islands area during the northern winter.

Even though the atoll is in the zone of the east setting north equatorial counter current, the origin of the objects from Japan cannot be excluded. There are abundant examples of Japanese Junks drifting to Siberia, Alaska, Canada, mainland USA, Hawaii, the Marianas and Guam, Palau and even the Marshall Islands (Kakubayashi 1983).

Dispersal of Pumice during volcanic eruptions

The dispersal of pumice during volcanic events is common. Further, often very large cones of pumice are thrown up by the activity, which may form entire islands. Because of the unstable nature of the deposit, then, these islands are quickly eroded by wave action and the pumice become dispersed by wind and currents. Examples for this phenomenon can be found throughout the Pacific, with Fonuafo’ou (Falcon Island) in the Tonga Group, and Rabaul, New Britain (Johnson & Threlfall 1992) may be mentioned here. Contemporary reports indicate that the pumice layers sometimes were so thick that they formed a navigation hazard. Such has been reported for Rabaul 1878 (Hernsheim in Johnson & Threlfall 1992, p. 26). The explosion of the Cracatoa in 1883 is the most famous for its wide dispersal of pumice, creating floating pumice bed over 2m in thickness (Sachet 1955). The 1928 eruption of the Tongan submarine vent Fonuafo'ou generated a large amount of pumice and created saeveral large floating pumice fields. Most of the piece seems to have rafted to Fiji. It is of significance to mention, though, that among the mainly gravel-sized pieces of pumice ‘a few lumps up to 2 feet in diameter’ were observed (see discussion in PIP 1956, p. 18).

Table 2 Some of the volcanic eruptions in the Pacific Rim area after 1905 but before 1989 which released large amounts of pumice into the sea

Year	Volcano	Locality	Reference
1906	Tofua	Tonga Group	Wood 1932
1906	submarine vent	Hawaiian Group	Sachet 1955
1912	Niuafo’ou	Tonga Group	Jagger 1930; 1931; Lewis 1979
1927	Fonuafo’ou	Tonga Group	Spennemann 1992:I23
1929	Niuafo’ou	Tonga Group	Jagger 1930; 1931; Lewis 1979
1934	submarine vent	Minami-Satsuma	Yamanari 1935; Sachet 1955
1935	Niuafo’ou	Tonga Group	Jagger 1930; 1931; Lewis 1979
1936	Niuafo’ou	Tonga Group	Jagger 1930; 1931; Lewis 1979
1937	Tavurvur	Rabaul, New Britain, PNG	Johnson & Threlfall 1992
1937	Vulcan	Rabaul, New Britain, PNG	Johnson & Threlfall 1992
1939	Fonualei	Tonga Group	Spennemann 1992:aI23
1941-43	Tavurvur	Rabaul, New Britain, PNG	Johnson & Threlfall 1992
1943	Niuafo’ou	Tonga Group	Jagger 1930; 1931; Lewis 1979
1946	Niuafo’ou	Tonga Group	Lewis 1979; Rogers 1986
1947	Niuafo’ou	Tonga Group	Jagger 1930; 1931; Lewis 1979
1953	Tulumuan	Manus Group, PNG	Reynolds *et al.* 1980
1974	Fonualei	Tonga Group	Spennemann 1992:I23

Such a pumice field was reported for the Marshall Islands in 1894 (Steinbach 1894), with no apparent volcanic source in the vicinity.

If we accept the dating argument advanced in the previous section, then all volcanic eruptions after 1905 may be likely candidates of origin for the large pumice item. Table 2 summarises the volcanic events in the Pacific Rim area, which released large amounts of pumice into the sea.

In addition to the sources spelled out in table 2, it is likely that a Hawaiian sources may have provided the pumice. Helene Sachet, in her compilation on the occurrence of pumice on islands, quotes C. Elschner (1915) as follows:

> [In March or April] "1906…, Captain Schlemmer at that time in charge of the phosphate works on Laysan Island… mentioned in his dairy that he observed a quake was to be felt and on the following days the sea was full of drifting pumice stone pieces. On his trip from Laysan Island to Honolulu he observed these pumice stone pieces as far as the neighbourhood of the main group near Kauai." (Sachet 1955, p.5)

The presence of freshly erupted pumice on Laysan, an atoll in the northern Hawaiian Group, suggests a source in the northern to central Hawaiian Chain. As none of the surface volcanoes is known to have erupted at the time, a submarine vent is likely. Submarine vents, are on record as having emitted large amounts of pumice. Fonuafo'ou and Fonualei in the Tongan Group are two good examples, the 1934 eruption of a submarine vent in the Minami-Satsuma another (Yamanari 1935, quoted after Sachet 1955). Some of these sources have a history of repeated eruptions, building up very large islands made up of pumice, and subsequent erosion below the water level.[1]

During the 1907 typhoon event on Woleai (Carolines) an earthquake occurred, probably triggered by the differential weight loading above the island during the cyclone. After the event a large amount of pumice was found floating in the area. An eyewitness, the German government physician Ludwig Born, assumed that a volcanic event caused the appearance of the pumice. But in the absence of any known active submarine vents it is also possible that the pumice comes from a very different source: subfossil pumice beads washed out and resuspended by the storm surge of the typhoon. Such pumice beds have been observed for example on Majuro Atoll, buried under 100-120 mm of sand (pers. obs.), which can easily be suspended by storm surge generated wave action.

Given that only limited marine growth was found on the piece of pumice and that there are no barnacles or coral sediments on it, it can be concluded that the pumice was not exposed to the seas for a very long time.

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1 Fonuafo'ou or Falcon I. (19°s and 175°25'W) is typical of submarine vocanoes. It was recorded as an island by the Spanish explorer Maurell in 1781 and as a shoal by HMS *Falcon* in 1867. HMS *Supply* saw smoke emanating from the sea in 1877, suggesting submarine activity not yet having breached the surface. After various eruptions in 1884 it was visible in 1885 as a distict island consiting eintirely of volcanic ash and pumice. It reached its maximum size of approx. 2.5. km in length and 87m in height in 1887. It was formally surveyed by HMS *Egeria* in 1889, when it was found to be 46.5m high and 2.2 km long. By Apri 1894 it had become a low shoal. New activity in December 1894 threw up a other crater, 4.5 km long, 2.7km wide and 15m high. Quickly eroding away because of wind, waves and currents, after the volcanic activity ceased, it was reduced to a shoal by 1898. In 1900 it was found to be 2.5 m high above high tide and, while in 1913 it was again reduced to a shoal. After erupting again in 1927 and island of 3km in dameter and 160m height was created by 1930. By 1940 it was reduced to 6-10m in height and by 1968 it was again 20m below the water surface. (Compiled after: British Admiralty 1889; 1896; Firth & Davidson 1944, p. 28; Hoffmeister & Ladd 1928; Lewis 1978; Marden 1968, p. 367; PIP 1956, p. 18; 396-397; Thomson 1926, p. 367; Wharton 1890).

Similar occurrences

There a few records in the literature which present a similar scenario of volcanic glass attached to a piece of pumice, showing that the case encountered on Nadikdik is not a solitary one.

Cocos/Keeling

Sachet (1995) quotes Guppy (1889) as stating that on an islands of Coco-Keeling a large piece of a volcanic bomb was found, which consisted of reddish cellular lava and a solid outer crust. The cellular components were found to float and Guppy assumed that the whole bomb had the potential to float.

Koil Island, Shouten Islands, PNG.

Obsidian attached to pumice was found on the beach of Koil Island in the Schouten Islands to the north of Wewak in Papua New Guinea. The obsidian is poor quality as a glassy band attached to a larger 25cm lump of pumice. The object appears to have been used as an abrading stone with a smooth hollow formed in the pumice (Ambrose pers. comm).

Bikini

Further perusal of the literature shows that the occurrence of obsidian adherent to a piece of pumice, as encountered on Nadikdik is not unique. In their detailed analysis of the beach sands of Bikini Atoll, Emery *et al.* (1954, p. 37) encountered fragments of volcanic glass among other material:

> "Other interesting, though rare, components of the beach sand were found in insoluble residues remaining after treatment with dilute hydrochloric acid. Rare sponge spicules were the only organic constituents recognised. Less expectable in the residues were many shards of glass, probably of volcanic origin, and for the most part containing small anisotropic acicular crystals. The index of refraction of the glass ranges from 1.52 to 1.58, and in some pieces it may be slightly beyond this range. The shards range in size from 10 microns or less, to one grain of about 1.5 millimetres length. They probably are not from broken bottles left on the Bikini beaches, because samples of similar bottles contain no incipient crystals. probably the volcanic glass arrived at Bikini as floating pumice, because at least three specimens of pumice or cinder were picked up on the beaches of Bikini and nearby atolls. One piece, 3 inches in length, however, as found to consist of glass unlike that in the beach sand. It may possibly be cinder from a ship's firebox." (Emory *et al.* 1954, p. 37).

Oahu

Upon following up this lead, it became apparent that most volcanic ejecta seem to contain volcanic glass in minor quantities. Volcanic ashes on Hawaii commonly contain very small glass components (Stone 1933). Wentworth (1926, p. 95) mentions that

> "In its unaltered condition, the black ash of Oahu consists of nearly jet black droplets [usually very small and less than 1 inch in size], and broken stringlets of vesicular volcanic glass. The vesicles are commonly elongate in the direction of extension of the plastic material as the droplets were formed."

Even though the quantities of volcanic glass encountered in the Bikini example are minute, the principles of potential seaborne transport of obsidian are underpinned.

Sourcing the Obsidian

The following sourcing of the obsidian was conducted by Wal Ambrose (ANU): The pieces of obsidian attached to the Koil and Nadikdik pumices were compared to known obsidian sources in the Pacific region.

The quantitative chemical analyses of Nadikdik, Koil and Tuluman (NKT) and other source obsidian specimens were made with a JEOL Scanning Electron Microscope equipped with Link Analytical PCXA energy dispersive spectrometer, employing ISIS Cambridge software. The specimens were sectioned and prepared as flat polished surfaces to avoid surface contamination. The major elements determined with this system were Na, Mg, Al, Si, Cl, K, Ca Ti, Mn and Fe. As manganese is poorly measured in these results it was excluded from the multivariate analysis The normalised results presented as oxides are shown in table 1. The immediate difference of the NKT pieces is their higher percentage of Mg, Cl, Ca and Ti compared with the other 13 specimens. The silica content of all these glasses, greater than 69% clearly distinguishes them from the lower silica content basaltic selvedge glasses from Pacific Basin sources such as those from Tonga, Samoa and Hawaii. These are therefore excluded as possible sources for the Nadikdik-Koil pieces.

Under some circumstances the chemical linking of the NKT collection would not be secure, being based solely on the use of nine major elements when these occurring most obsidians within a relatively narrow compositional range. The geological report of the Tuluman rocks (Reynolds *et al*. 1980,p. 43) describes them as being alkali-rich rhyolites similar in composition to those found in the adjacent inhabited Lou and Pam Islands, nevertheless the analyses presented here clearly differentiate the Tuluman obsidian from those of Lou-Pam. A multivariate correspondence analysis (Hintze 1996) graphically demonstrates the separation of the Nadikdik, Koil and Tuluman group from all the other analysed specimens (figures 17 and 18). The tight clustering of the NKT collection and its clear separation from a wide range of other southwest Pacific sources is a good indication of their common origin in the Tuluman island volcanic eruption of 1953 to 1957.

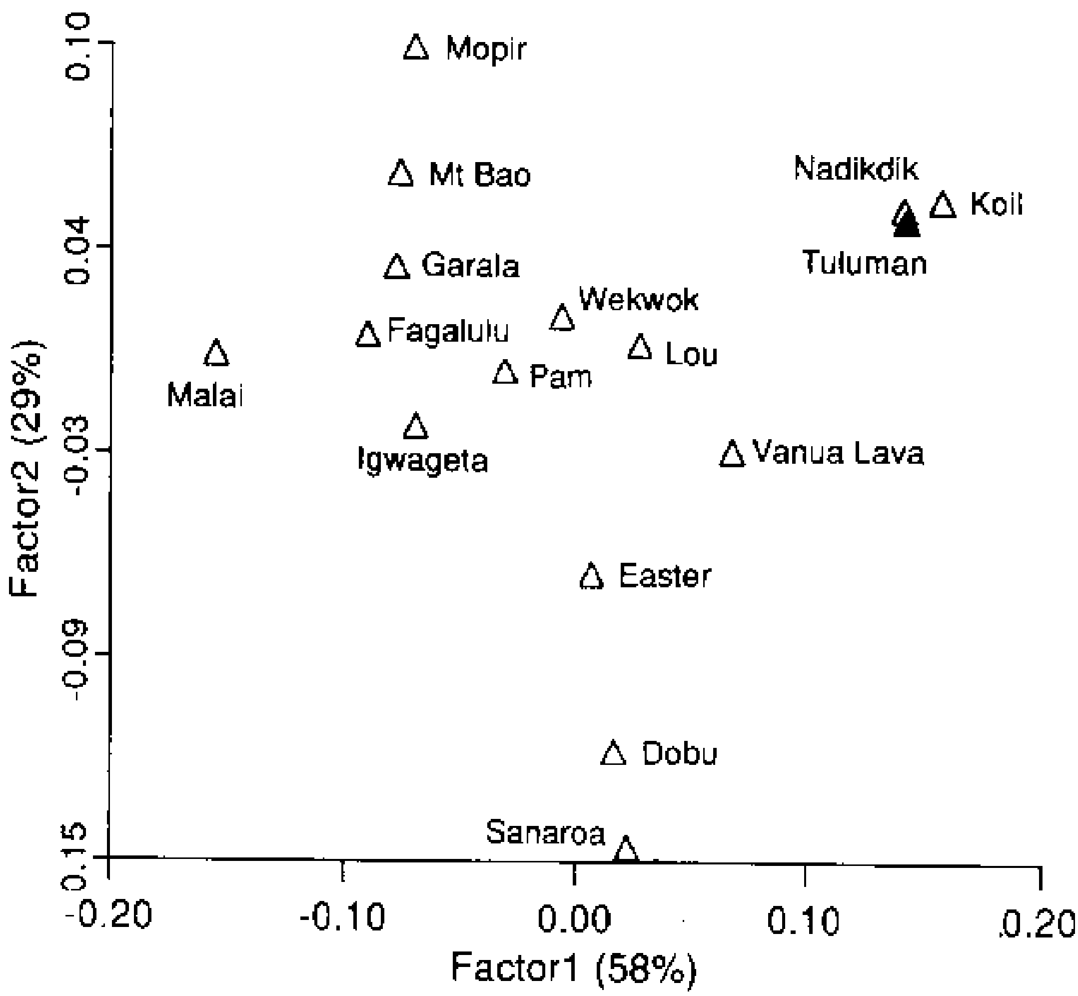

Figure 17. Correspondence analysis of principal elements in the obsidians from Koil Island and Nadikdik in relation to known obsidian sources.

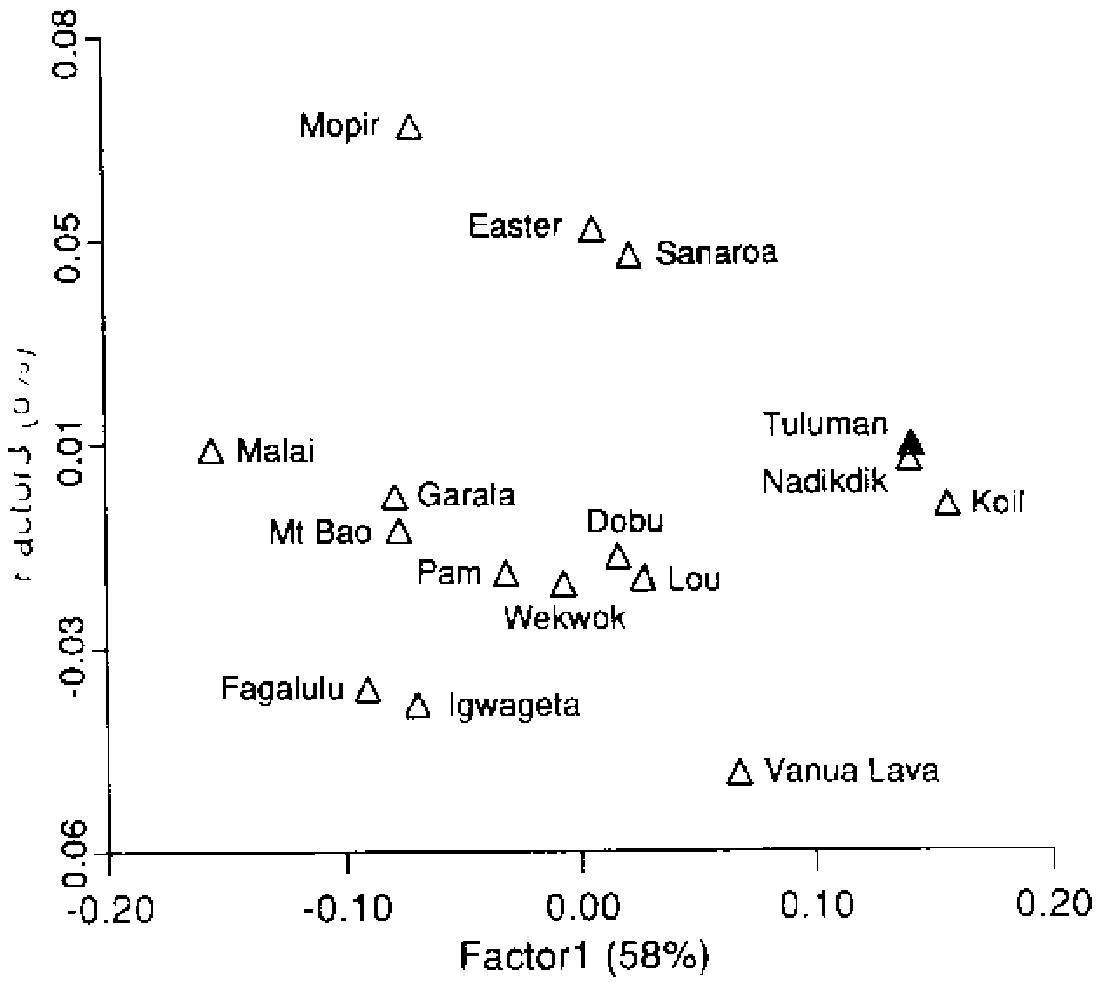

Figure 18. Correspondence analysis of principal elements in the obsidians from Koil Island and Nadikdik in relation to known obsidian sources.

Reynolds and others (1980, p. 20) describe the floating pumice beds up to several metres across associated with intermittent submarine eruptive activity on 24th of March 1955 and this clearly demonstrates that conditions were suitable for the long-distance drifting of rafts of pumice and its entrained obsidian.

Most of the sources in Table 3 were capable of producing pumice and some still do from the coastal weathering of former volcanic deposits, but only the Tuluman source matches the Koil and Nadikdik specimens. This then implies a sea rafting of the pumice from the Bismarck Sea to the Marshall Islands (figure 19).

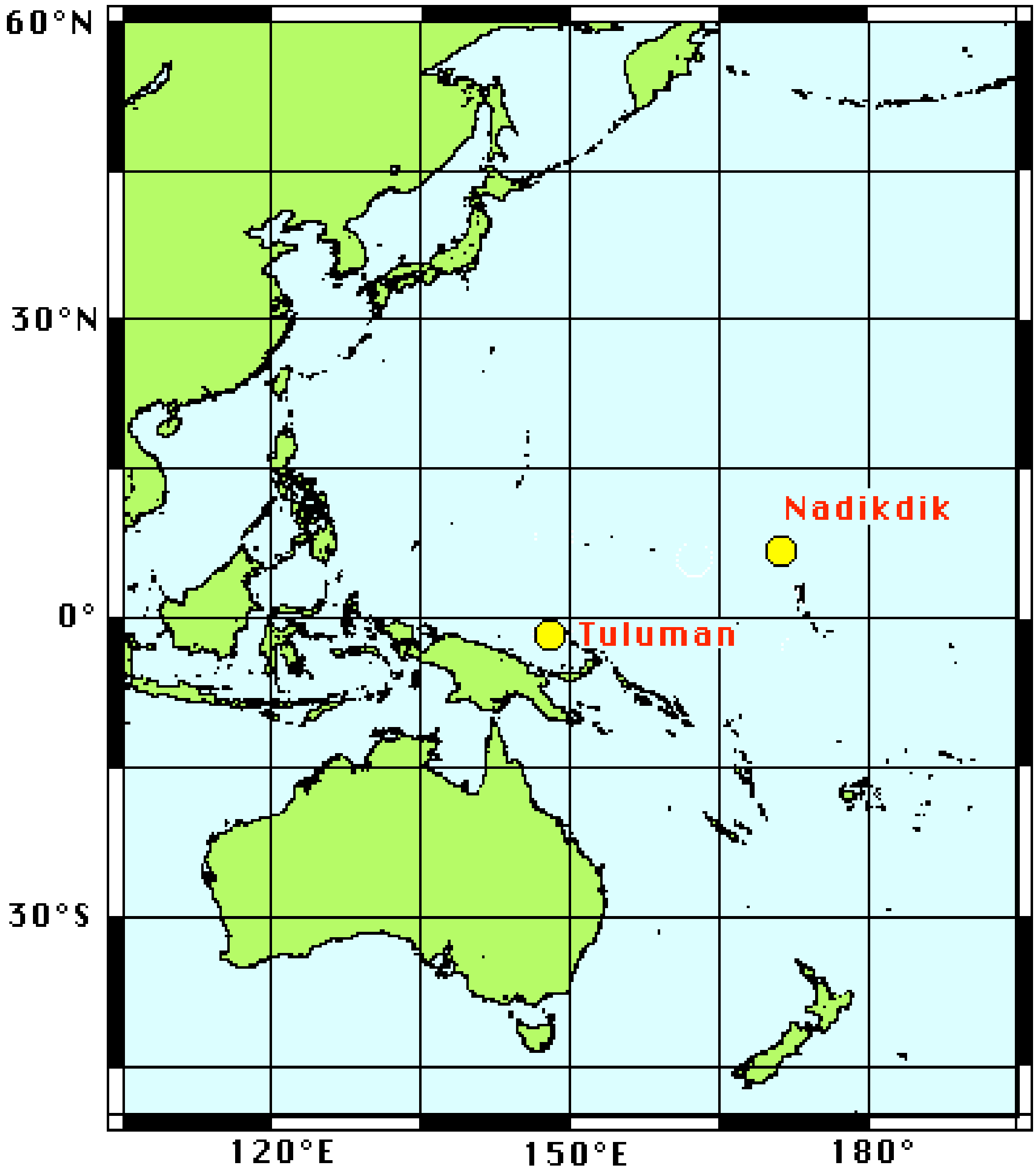

Figure 19. Map of the Pacific Ocean showing the location of Tuluman Island and Nadikdik Atoll.

Table 3. Major element EDAX analysis of the pumice-rafted obsidians from the 1950s Tuluman eruption and the distant beach finds from Koil and Nadikdik, to be compared with 13 other known sources from the southwest equatorial region, and one from the major Easter Island source at Motu Iti. The analyses, with the exception of Garala are multiple determinations (n.x) with standard deviation listed below (sd).

		Na_2O	MgO	Al_2O_3	SiO_2	Cl	K2O	CaO	TiO_2	MnO	FeO
Tuluman Is	(n 4)	5.22	0.47	14.01	70.57	0.50	3.37	1.83	0.49	0.13	3.41
1950s eruption	sd	0.13	0.01	0.06	0.33	0.03	0.06	0.05	0.10	0.09	0.15
Koil	(n 2)	5.59	0.60	14.11	69.94	0.53	3.42	1.86	0.51	0.12	3.35
(Schouten Is.)	sd	0.11	0.09	0.18	0.50	0.05	0.02	0.16	0.01	0.07	0.27
Nadikdik	(n 5)	5.38	0.49	14.06	70.44	0.49	3.37	1.88	0.46	0.10	3.32
(Micronesia)	sd	0.17	0.02	0.05	0.07	0.02	0.07	0.13	0.07	0.11	0.13
Wekwok	(n 15)	4.90	0.20	13.77	73.28	0.31	4.16	1.10	0.31	0.04	1.94
(Lou Is.)	sd	0.15	0.03	0.07	0.14	0.02	0.07	0.05	0.03	0.05	0.10
Umleang	(n 15)	5.20	0.23	14.17	72.06	0.33	4.10	1.21	0.33	0.04	2.33
(Lou Is)	sd	0.07	0.03	0.07	0.16	0.03	0.07	0.07	0.05	0.06	0.10
Pam Lin	(n 5)	4.88	0.12	13.43	73.91	0.32	4.41	0.86	0.28	0.03	1.77
(Manus)	sd	0.09	0.03	0.06	0.16	0.03	0.05	0.08	0.05	0.09	0.10
Malai	(n 2)	4.72	0.03	13.04	77.22	0.07	3.90	0.26	0.09	0.13	0.56
(Manus)	sd	0.01	0	0.13	0.11	0.01	0.01	0.01	0.05	0.09	0.08
Mt Bao	(n 6)	3.97	0.17	12.78	76.44	0.17	3.93	1.13	0.26	0.04	1.11
(New Britain)	sd	0.13	0.01	0.05	0.12	0.02	0.05	0.05	0.03	0.05	0.07
Garala	(n 1)	4.22	0.10	12.66	76.11	0.16	4.11	0.96	0.25	0.13	1.30
(New Britain)											
Mopir	(n 2)	4.36	0.19	12.33	77.89	0.08	2.34	1.35	0.25	0.06	1.17
(New Britain)	sd	0.25	0.01	0.08	0.13	0.01	0.02	0.09	0.11	0.01	0.04
Dobu Is.	(n 2)	6.37	0.18	14.35	70.39	0.12	4.95	0.30	0.27	0.06	3.04
(E. Fergusson)	sd	0.11	0.01	0.06	0.29	0.02	0.09	0.04	0.07	0.02	0.11
Sanaroa Is	(n 4)	5.93	---	12.55	72.00	0.05	4.96	0.31	0.28	0.13	3.81
(E. Fergusson)	sd	0.13	---	0.11	0.06	0.03	0.05	0.02	0.05	0.08	0.04
Igwageta	(n 4)	5.23	0.16	14.51	73.20	0.03	4.55	0.68	0.29	0.04	1.35
(W. Fergusson)	sd	0.02	0.04	0.11	0.10	0.03	0.04	0.03	0.06	0.05	0.04
Fagalulu	(n 2)	4.86	0.20	14.06	74.52	0.02	4.33	0.75	0.23	---	1.08
(W. Fergusson)	sd	0.18	0.03	0	0.17	0.01	0.11	0.01	0	---	0.05
V Lava Is.	(n 2)	4.37	0.23	14.12	70.80	0.28	5.23	1.45	0.26	0.08	3.21
(Banks Is.)	sd	0.05	0.17	0.35	1.08	0.03	0.19	0.6	0.14	0.09	0.82
Motu Iti	(n 4)	5.81	---	13.2	72.98	0.22	3.88	0.70	0.23	0.09	2.93
(Easter Is.)	sd	0.07	---	0.18	0.3	0.02	0.10	0.13	0.07	0.03	0.08

Extraneous materials in the Marshalls

The atolls making up the Marshall Islands are full atolls, with no volcanic cores exposed at any accessible location. Thus the entire range of naturally occurring raw materials available to the Marshallese is derived of calcium carbonate, either in form of coral or in form of shells. The substrate of the islands is made up of calcium-carbonate cemented coral conglomerates ("beachrock"), and the soils are made of their erosion products, sand, mixed with rather limited organic material derived from decomposed vegetative matter. Any material of volcanic origin has to come in from the outside, be it via human transport, current transport or trapped in other objects. Let us now have a look at the types of extraneous materials brought into the Marshall Islands and the uses they found there. The materials discussed in the next sections will be soil, volcanic rock, pumice, driftwood, drifted canoe hulls and Japanese glass floats.

Exploitation of drift material was a common procedure in the Pacific. The Tongans, for example, relied on washed up Sperm whales for their supply of ivory (Martin 1817). Drift material washed ashore in the Marshall islands was much sought after resource. At the time of European contact shipwrecks and flotsam were the property of the chiefs. In Marshallese custom, the reefs, especially those where fishing was good, belonged to the *irooj*, who could claim them unilaterally (Tobin 1952, p. 11). The property rights of each wato extended as far into the lagoon as one could stand, commonly waist-deep. In the 20th century, it seems, the *irooj* of the abutting land had customary rights to all flotsam and jetsam and ligan washed ashore (Tobin 1952, p. 12).

Soil

Imports of soil to the atolls of the Marshall Islands seems to have occurred mainly in the form of ship's ballast, brought by copra trading vessels returning partially empty from the volcanic high islands in the Carolines (such as Ponape) (*cf*. Fosberg 1961). Import of soil from high islands on Jaluit Atoll, mainly to run the experimental garden located at the German capital. The import was conducted by both by the Germans and the Japanese (Fosberg & Sachet 1962, p. 1; Stevenson 1914, p. 150). The import of soil as ships ballast, however, did apparently not occur on a regular basis. The German colonial report for 1895 mentions that "the high cost of earth when a ship chances to bring ballast into the harbour prevents the extension of the gardens" (Anonymous 1895). During the period of Japanese administration, import of soil directly from Japan has been reported (Price 1935, p. 256). Post-World War II import of soil occurred to Kwajalein (Sachet 1955, p. 19). "German" soil is also reported to have been imported to Japtan Island, Enewetak Atoll (Lamberson 1987, p. 24), and Majuro (Erkelens 1990—own research could not hitherto substantiate this claim). The Japanese, intent on staying for a long time, imported night soil from Japan to improve the soil on both Eneen-Kio (Wake) and Wotje Atolls (Kephardt 1950, p. 34). Import of the same material can be assumed for two, or three other major Japanese bases, namely Kwajalein/Roi-Namur, Taroa (Maloelap Atoll) and Jaluit. These soil imports are likely to have been very small, just confined to gardening plots.

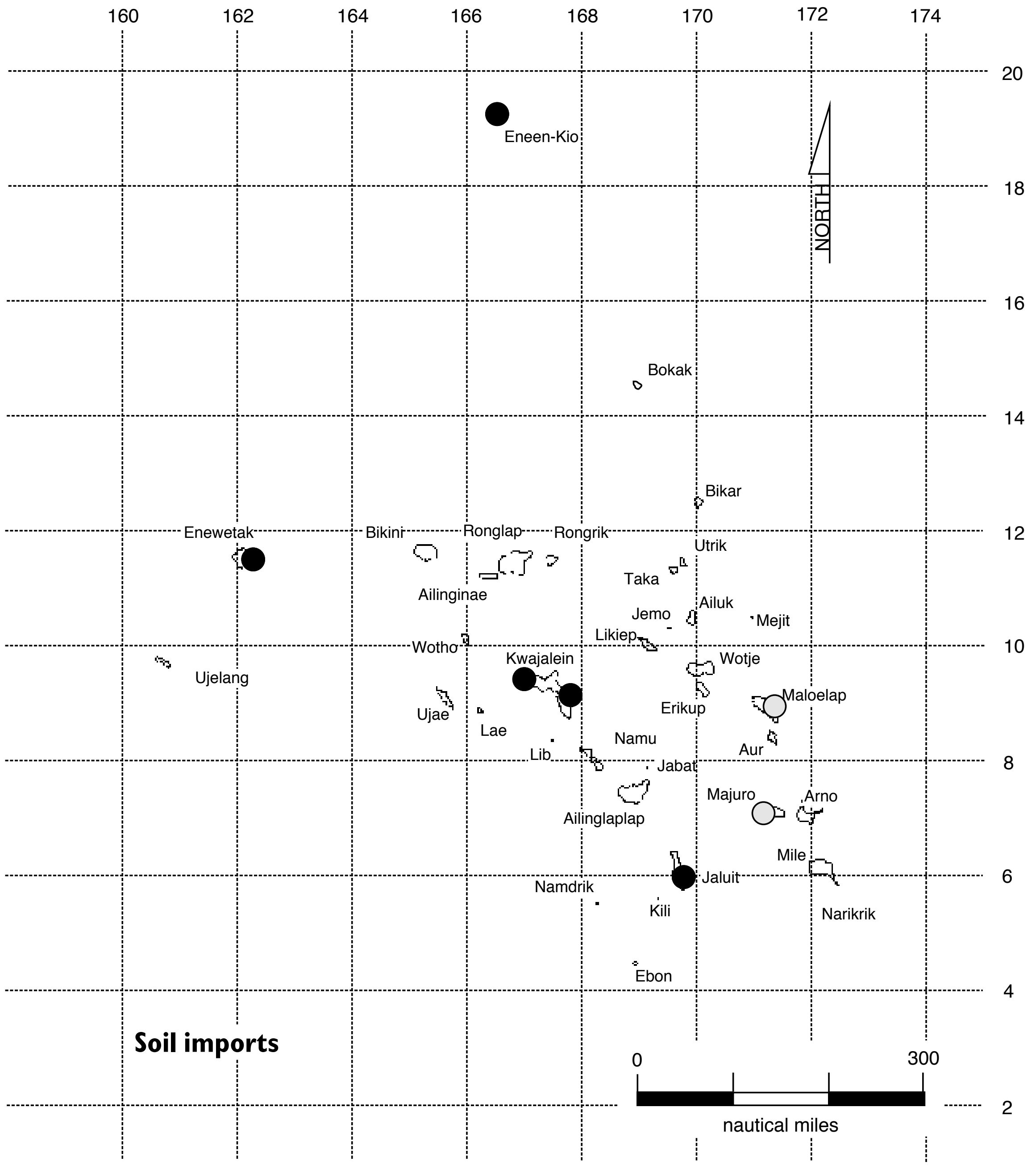

Figure 20. Map of the Marshall Islands showing the distribution of recorded occurencees of soil imports.

Volcanic stones

Although the atolls of the Marshall Islands are entirely made up of coralline material, there some reports of volcanic stones found on the surface. The larger ones are usually interpreted as imports by people, while smaller ones may have arrived by accident, such as stones caught or entangled in the root area of driftwood trees. A record of a basalt boulder found on Bokak (Cameron 1923, p. 397) seems to have been a faulty identification of blackened coral boulders (Sachet 1955, p. 16; Fosberg 1955a, p. 3; 28).

Traditionally basalt blocks (columns?) are also known from Namu and Aur. The basalt block on Namu, named "Lutwätonmour" (long-life giver), was originally located on the wato Bokar. The stone is said to have been removed by the vessel *Morning Star*, as the stone had considerable ritual importance and was said to be the origin of the early chiefs of the Ralik Chain (Erdland 1914, p. 345; Krämer & Nevermann 1938, p. 41). Another basalt block, named "Lidebreja" and said to be the "sister" of the one on Namu, was known on Aur (Erdland 1914, p. 345; Krämer & Nevermann 1938, p. 74). Given the contacts the Marshallese had with Kosrae and Pohnpei, an import from there is quite possible.

During a geomorphological survey of Taroa, Maloelap, a few pebbles of volcanic origin (igneous rock) were found near a wall of the main generator building. The origin of these can be explained in two ways: either they were part of some construction material imported by the Japanese, or they stem from the root complex of a driftwood tree which came from a volcanic or high island (Spennemann 1989b).

Wells (1951, p. 3) reports that one driftwood tree seen by him on Arno in 1950 contained "sizeable chunks of quartzitic grey-green sandstone" in its root network. *Extraneous rock* was encountered during the INRS survey of Mile Atoll only once. As a extraneous material a boulder of volcanic rock of unknown origin and purpose measuring some 0.3m in diameter was seen on the western section Burrh Island (pers. obs.). Rosendahl had found flakes of volcanic rock during archaeological surveys on Ebon (two specimens) and Majuro (one specimen; Rosendahl 1987, p. 120; 122-123).

Traditional uses

Where possible, island populations living on coral limestone islands or coral atolls attempted to obtain volcanic rock for tool manufacture. The acquisition of volcanic stones from other islands has been documented *inter alia* for Ant Atoll (near Pohnpei; Sachet 1955), Woleai Atoll (Chamisso 1821, p. 104), and Ifalik Atoll (Carolines; Sachet 1955). In some instances, where a systematic acquisition from volcanic islands could be maintained over a prolonged period of time, the use of volcanic rock has been very common (cf. Tonga: Spennemann 1986a; 1991b).

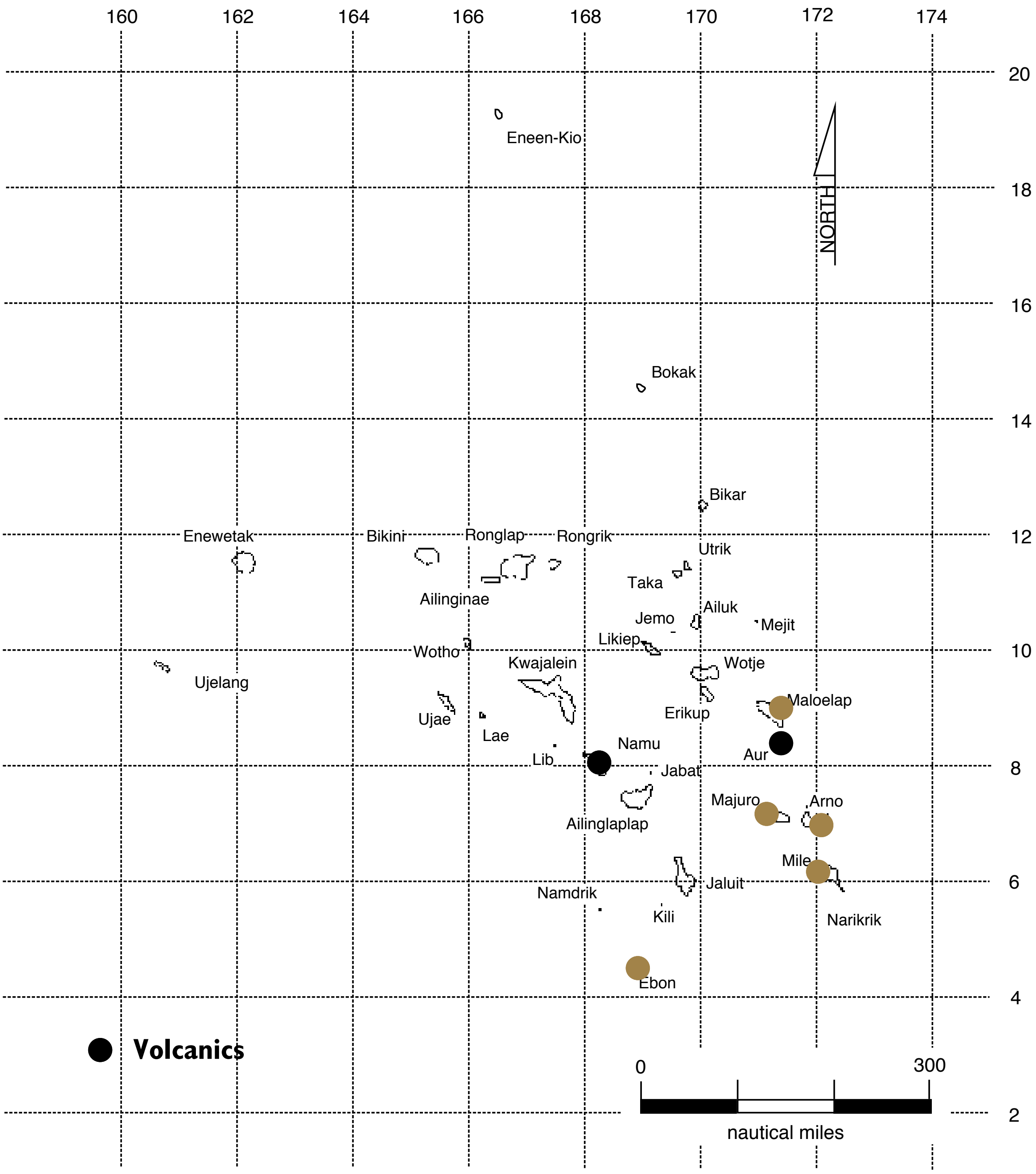

Figure 21. Map of the Marshall Islands showing the distribution of recorded occurencees of volcanic rocks.

Stones caught or entangled in the root area of driftwood trees have traditionally been used as a source of raw material in the Marshall Islands and on other atolls of Micronesia. *dekã non* were the heavy volcanic stones necessary for the *um*, the earth oven, while *tilaan* is the term for ordinary pumice Chamisso (1986, p. 139) describes that large stones used for grinding shell adzes are commonly obtained from driftwood trees and mentions that any such stones found had to be given to the irooj at punishment of death (Chamisso 1910, p. 168). Finsch (1893, p. 66; 154) as well as Krämer & Nevermann (1938, p. 145) question whether large stones could in fact stem from such sources. Apart from stones, also pieces of iron were found by the Marshallese in driftwood parts of wrecked European vessels (Chamisso 1910, p. 168). Chamisso verified the Marshallese statement in this regard as he himself found planking with nails on Wotje. There is no recorded use of obsidian in the Marshall Islands at any time, but the use of glass flakes, when they became available has been documented by Chamisso (1821, p. 156; cited after 1910, p. 186), Kotzebue (1821) and Krämer & Nevermann (1938, p. 145). Their main use was for carving and scraping of wooden items.

Pumice

In the literature, pumice is reported for a number of atolls in the Marshall Islands (see table 4). The first observation of pumice in the Marshall Islands was made by Chamisso (1821, p. 156; cited after 1910, p. 186), possibly on Ailuk Atoll. The occurrence of pumice appears to be temporal, dependent on volcanic eruptions in nearby areas. Grundemann (1887, p. 442) mentions large pumice beds for Ailuk. It is possible that this occasion was caused by the explosion of the Cracatoa in 1883 and that the pumice was moved there by the currents. This is asserted by Elschner (1915, quoted in Sachet 1955, p.5). Steinbach (1894) mentions that an especially large number of pumice were washed ashore in Jaluit and other parts of the Marshall Islands in September 1894. At the time, ships are said to have driven/sailed through large fields of drifting pumice stone.

There appears to be a clear distinction between the pumice seen on the surface and the pumice seen buried. All buried pumice seen by the author was of a brownish colour, while all pumice found on the surface was of a dark greyish to greyish-black colour. It is possible that this colour distinction is caused by the increased oxidisation of the iron contents in the pumice when subjected to a continuous regime of moisture. A buried pumice bed was seen on Majuro Island (Laura) Majuro Atoll in 1991. The bed is covered by about 0.2m-0.3m of sand.

This distribution of pumice records in the RMI shows no spatial distribution in favour of one geographical area. The sizes of the pumice varied from the small scattered pebbles, to football-sized pieces (Sachet 1955).

On Arno Atoll (Stone 1951, p. 10; Wells 1951, p. 3), where it occurred both high up on the beaches of the lagoonal and ocean side, as well as inland. Wells (1951, p. 3) reports sizes “from small pebbles to the size of one's head.” During the INRS survey of Arno Atoll, pumice was seen on Kilomman and on Arno Islands. The pumice on Kilomman was found on the northern tip of the island, lying on the surface of the beaches (in the strand vegetation zone) and in the centre. The pumice occurred in medium to large sizes, measuring up to 15cm in diameter, was of small to medium sized porosity (mainly 1-2 mm, some up to 5mm), and of greyish colour with black inclusions. The pumice seen on Arno Island was found in a buried deposit in the centre of the island, exposed in trenches dug on the (then) Taiwanese Experimental Agricultural Farm. This pumice was of fine porosity (1-2 mm) and of a yellow colour.

Table 4. Records for unworked pumice in the Marshall Islands

Atoll	Island	Year	Colour	Location	Reference
Ailuk		1816			Chamisso 1910:186
Ailuk		1886			Grundemann 1887:442
Ailuk		1950s			Fosberg 1955; Sachet 1955:2
Arno		1950s			Stone 1951:10; Wells 1950:3
Arno	Arno	1991	black	surface	Spennemann unpubl.
Arno	Arno	1991	orange	buried	Spennemann unpubl.
Arno	Kilomman	1991	black	surface	Spennemann unpubl.
Bikini	Bikini	1946/7	?	surface	Emery *et al*. 1954:37
Bokak		1950s			Fosberg 1955; Sachet 1955:2
Ebon	Ebon	1992	d.gray	surface	Spennemann pers. obs.
Eneen-Kio	Peale			surface	
Enewetak		1980s		surface	Coln 1987:31
Jaluit		1894		surface	Steinbach 1894
Jemo		1950s			Fosberg 1955; Sachet 1955:2
Kwajalein		1950s			Fosberg 1955; Sachet 1955:2
Kwajalein	Ebadon	1993	black	surface	Spennemann 1993
Kwajalein	Mejatto	1993	black	surface	Spennemann 1993
Majuro	Ajeltake	1989	black	surface	Spennemann unpubl.
Majuro	Enumanet	1990/2	black	surface	Spennemann unpubl.
Majuro	Laura	1989	brown	buried	Spennemann unpubl.
Majuro	Rongrong	1989	black	surface	Spennemann 1989c
Maloelap	Taroa	1989	black	surface	Spennemann 1989b
Maloelap	Eoon-epje	1989	black	surface	Spennemann 1989b
Mile	Bokwa-en-keaar	1991	black	surface	Spennemann unpubl.
Mile	Garu	1991	black	surface	Spennemann unpubl.
Mile	Lukunor	1991	black	surface	Spennemann unpubl.
Mile	Mile	1991	black	surface	Spennemann unpubl.
Mile	Nalu	1991	black	surface	Spennemann unpubl.
Mile	Obo-en	1991	black	surface	Spennemann unpubl.
Mile	Tokowa	1991	black	surface	Spennemann unpubl.
Nadikdik	Aleon-eo	1991	black	surface	this paper
Nadikdik	Aleon-kan	1991	black	surface	this paper
Ujae		1950s			Fosberg 1955; Sachet 1955:2; Fosberg & Carroll 1965:Plate 23c
Ujelang		1950s			Fosberg 1955; Sachet 1955:2
Utirik		1950s			Fosberg 1955; Sachet 1955:2
Wotho		1950s			Fosberg 1955; Sachet 1955:2
Wotje	Wotje	1992	black	surface	Spennemann unpubl.
Wotje	Wotje	1992	black	surface	Spennemann unpubl.

Pumice was found during the INRS of Mile Atoll on a number of islands. Most of the pumice seen was of grey to grey-black colouration and of a size smaller than a man's fist. Pumice was seen on the following islands of Mile Atoll: Bokwa-en-keaar, Obo-en, Garu, Mile, Nalu, Lukunor and Tokowa. In addition, it was encountered on Aelon-eo and Aelon-Kan on Nadikdik Atoll (perds. obs.). In addition, pumice was seen on Mile in 1992.

Chemical analyses are given for Bokak, Jemo, Ujae, Wotho, and Ujelang (Sachet 1955, p. 21). All samples were ignited at 900°C for 15 minutes. The analysis (table 5) showed that

Table 5. Spectrographic analyses of pumice found in the Marshalls 1951-52 (Sachet 1955)

Location	Jemo	Jemo	Jemo	Ujae	Ujelang	Ujelang	Wotho	Bokak
Colour	white	dark	black	pale grey	grey	grey	grey	grey
Texture	medium	fine	coarse	medium	medium	medium	medium	medium
Cu	0.009	0.003	0.009	0.003	0.002	0.003	0.001	0.001
Mn	0.1	0.2	0.1	0.1	0.09	0.1	0.1	0.1
Co	0.0009	0.002	0.002	0	0.001	0.001	0	0
Fe	3.3	7.7	5.3	2.7	3.6	3.5	2.9	3.4
B	0	0	0.004	0	0	0	0.002	0.002
Mo	0	0	0	0	0	0	0	0
Zn	0	0	0	0	0	0	0	0
P	0	0	0	0	0	0	0	0
% Loss*	2.2	1.0	0.14	4.3	3.4	4.6	4.1	4.1

* Loss on ignition.

The movement of drift material from the southern to the northern hemisphere is not uncommon. Following the explosion of the Cracatoa in 1883 large amounts of pumice were produced which were washed ashore on Nauru, but also the Marshall Islands and even on the atolls of the northwestern Hawaiian Islands (Elschner 1915, quoted after Sachet 1955).

In Zealand there is ample evidence of past events entailing large amounts of sea-rafted pumice, such as Loisel's pumice and Taupo pumice, which form huge deposits (eg. Pullar *et al*. 1977; McFadgen 1985).

Traditional uses

Traditionally, pumice had two principal uses in the Marshall Islands: i) it was used as a fertiliser in taro patches, either unmodified or in pounded form. This has been described for Ailuk Atoll by Grundemann (1887, p. 442); and ii) more commonly it served as abraders and grinding material for the manufacture of shell beads (Krämer & Nevermann 1938, p. 145; 147).

Pumice abraders have been found in archaeological sites in Arno, Majuro, Aur, Ebon, Lae, Likiep, Maloelap and Mile by Rosendahl (1987, p. 120; 122-123).[1]

Throughout the Pacific pumice has been a resource which was exploited for a variety of purposes: **Fertilisation with pumice** has been reported for Kiribati (Sachet 1955, p. 12); and in the Indian Ocean for the Cocos-Keeling Islands (Guppy 1889, cited after Goetz 1914, p. 29). The capacity of pumice to float was used to manufacture **net floats** in New Zealand (Bellwood 1978, p. 45; Davidson 1984, p. 71; Leach 1979, p. 96; 99; Leahy 1976, p. 58; Skinner 1923, p. 101)

1 Rosendahl's argument to include all rounded pieces in his classification as artefacts is not warranted. Pumice can be abraded by normal environmental action, such as rain and wind, as well as by wave action if pumice is deposited in a zone frequently reworked by cyclical (spring) high tides.

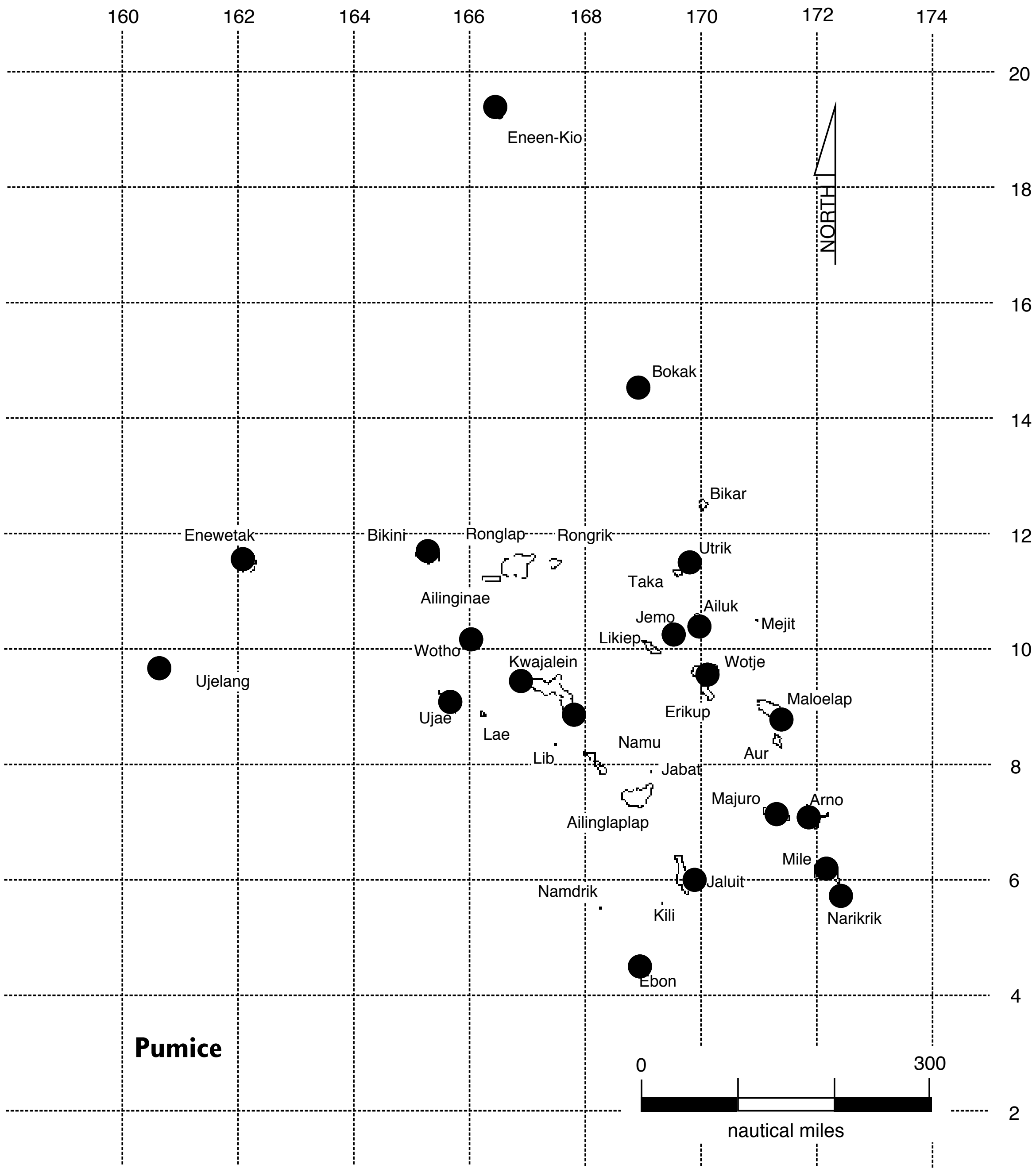

Figure 22. Map of the Marshall Islands area showing the distribution of recorded occurrences of pumice

The majority of recorded applications uses the fine grained coarseness of the pumice for **abrasive purposes**, mainly for wood working. This has been described for *Kiribati* (Koch 1965, p. 151). On *Hawaii* (Kirch 1985), where Te Rangi Hiroa (1964) describes the use of pumice as rubbers (abraders) to finish the outer surface of the canoe hull. For Hawaiian canoe builders the pumice abrader formed a medium coarse grade of abrader (n° 3) in series of six, ranging from coarse (fine coral, n° 1) to polishing stones (close grained basalt, n° 6).

New Zealand, where there is an abundance of pumice available, shows a great variety of otherwise more unique applications. There, pumice has been used for beads in necklaces (Davidson 1978, p. 221; 1979, p. 197-198; 1986, p. 79; Edson & Brown 1977; Leahy 1974, p. 40-42); as pigment containers (Davidson 1984, p. 109); as bowls (Davidson 1984, p. 109); and as gourd stoppers (Davidson 1984, p. 109). In addition, pumice blocks were apparently worked at some localities, presumably for export (Davidson 1984, p. 109) and shaped in form of objects (models?) commonly made of other materials, such as adzes and patu (Davidson 1984, p. 108-109).

Driftwood

The first European account for the occurrence of driftwood in the Marshall Islands is given by Chamisso who noted it on Wotje in 1816 (Chamisso 1910). Driftwood is a common occurrence on the atolls in the Marshall Islands (Hager 1886, p. 57). Driftwood has been reported from the shoreline of many atolls, such as Majuro (Spennemann 1990a; 1992), Arno (Wells 1951, p. 3); Mile (pers. obs.); Ebon (pers. obs.), Maloelap (pers obs.), Jaluit (Schneider 1891) and has also been found in the centre of others, such as Wake Atoll (Grooch 1936, p. 92; 1938) or Bokak Atoll (Irmer 1895), both in the northern Marshalls. Wells (1951, p. 3) who reports that driftwood trees arriving from North America (California) and carried by the Northern Equatorial Current are not uncommon. For Arno Atoll Wells mentions a cut fir log measuring 5 by 55 feet and a trunk of a redwood tree., and cut logs were also seen by the author on Majuro Atoll. Fosberg (1956, plate 13A) shows the root section of a driftwood tree on Kwajalein Atoll.

Long distance transport of material bring up some surprises. A driftwood tree washed ashore at Butaritari (Kiribati) in 1906 during a gale blowing from the west carried a crocodile (Krämer 1906, p. 319; 1927, p. 50), which must have come from the Solomon Islands, Palau or even further afield in the west. Given the position of Butaritari it is most likely that the tree was pushed by the southern equatorial counter current. Koch (1965, p. 170) mentions that driftwood from the Solomon Islands was a desired type of wood in Kiribati, which was washed ashore on the eastern side of the islands.

Let us now look at the occurrence of driftwood on Nadikdik and neighbouring Mile Atoll. The trees seen by the author can be summarised into three categories: cut driftwood logs, stemming from saw-milling operations along the coast of the Pacific Northwest, breadfruit trees some of which may originate from other locales in the Marshall Islands, and other tropical and northern trees which may come from the Pacific North West, Japan or SE Asia. *Cut drift logs* were a common occurrence during the INRS survey both on Mile Atoll and Nadikdik Atoll. They commonly measured between 1.0 and 1.5m in diameter and anything from 1.0 to about 15m in length. Cut drift logs were seen on the lagoonal sides of the following islands: Arbar, Bogukarik, Dobo-en, Enanlik, Lukunor (3 logs), Tokowa, and on the ocean side of Burrh all on Mile Atoll, and the islands of Aelon-eo, Nadikdik and Aelon-Kan on Nadikdik Atoll. *Other driftwood*, apparently mainly trunks from large breadfruit trees (*Artocarpus* sp.) were seen on the ocean sides of Dobo-en and Bokwa-en-keaar. On several islands on Mile (Garu, Namake and Enanlik) and Nadikdik Atolls (Aelon-eo) bamboo was found, some of which most likely stems from Japanese pole and line fishing vessels (pers. obs). Some of the driftwood trees seen had very large buttresses suggesting great age of the trees and documenting that not only saw logs have drifted ashore in the Marshalls (figure 21).

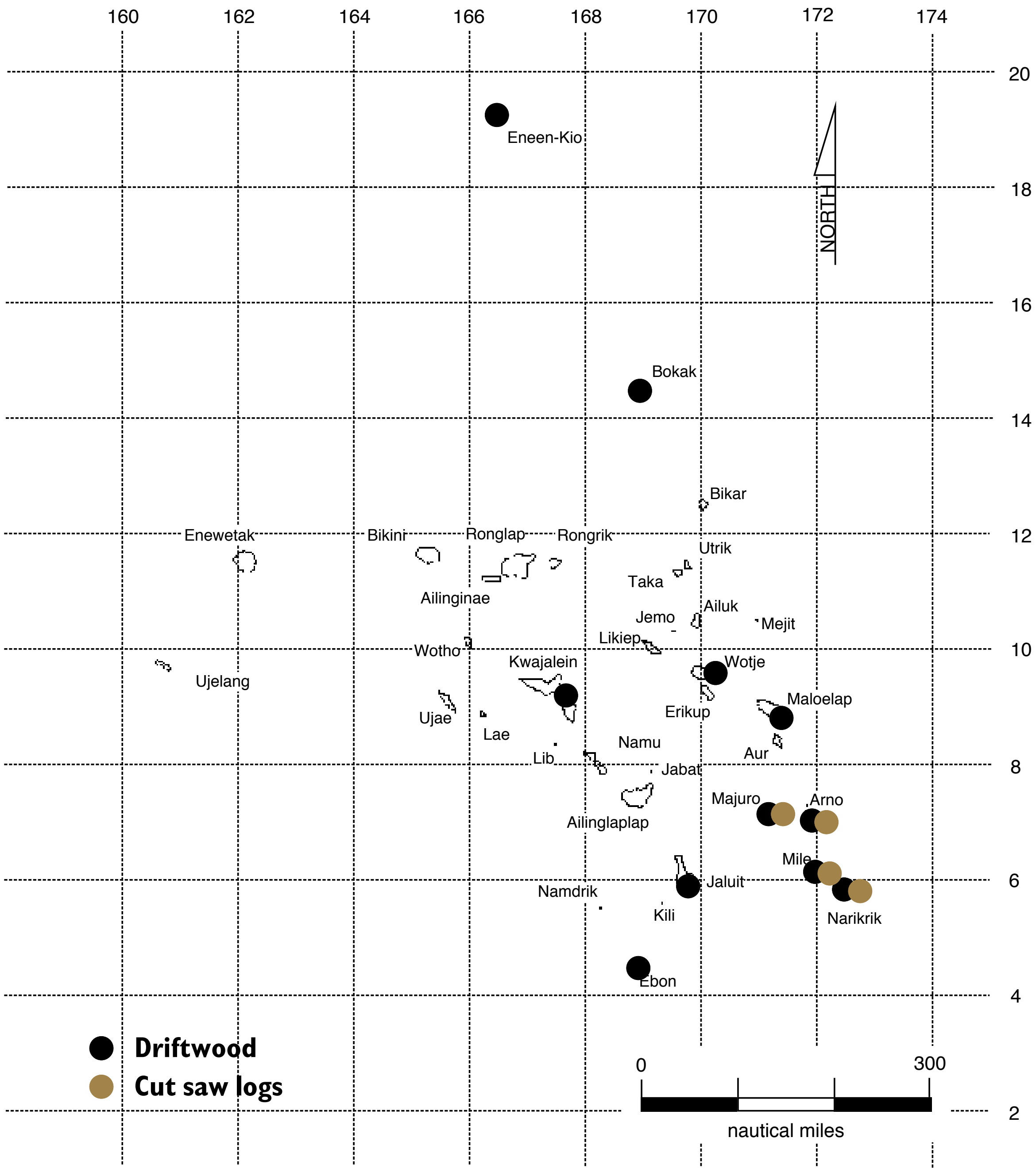

Figure 22. Map of the Marshall Islands area showing the distribution of recorded occurrences of pumice

Figure 24. Large driftwood tree on the ocean side of Rongrong Island, Majuro Atoll. Such tree can only be deposited during large storms. Note that the person standing in front of the tree is about 1.6m tall. Photo by the author

Traditional uses

The most common use of driftwood, once dried out, is obviously as fire wood, even though the heat value is low. The Marshallese language has two special terms for the cedar-type driftwood: *aik* (Abo *et al*. 1976, p. 6) and *kãmej* (Erdland 1914, p. 152) both of which were hard and resistant to insect attack (because of the resin content?). The hard cedar wood was often used for canoe (Erdland 1914). In addition to the wood itself, the resin nodules (*küor*) were sought by the Marshallese, as they gave of a sweet scent when warm, and as (Erdland 1914, p. 152).

On the other hand, the drift wood *kãnõna* is a soft kind of wood of little use (Erdland 1914, p. 152). A starvation food (*buiabui)* could be made by pounding the internal part of a soft driftwood tree to pulp and then mix ing it with arrow root flour and water. A variation of this seems to be to pound the internal wood of an old coconut palm and mix it water and with arrowroot flour. Such a dish basically added fibrous material acting as stomach filler to arrowroot starch (carbohydrates; Spennemann 1992f).

Much sought after was rafted bamboo for use as bamboo containers for needles, glowing coals and the like, for use as spears and for fishtraps (slithers; Krämer & Nevermann 1938; Knappe collection Erfurt, unpubl.) . Bamboo is now grown on the Marshall Islands, but it has been imported by the Japanese during their colonial period (Fosberg 1990). It is possible that the rafted bamboo came from sources in Indonesia or the Philippines.

In Kiribati driftwood is for fish floats (Koch 1965, p. 43) and especially for outrigger floats (1965, p. 170). Koch (1965, p. 170) mentions that driftwood from the Solomon Islands was a desired type of wood to be used in Kiribati canoe manufacture (*kuia*, the best wood on the islands), which was washed ashore on the eastern side of the islands.

Canoe hulls and drift voyages

Canoes and canoe hulls are other indicators of drift materials in the Marshall Islands. The author has seen two canoe hulls which appear to be from Solomon Islands canoes. One was seen on Mile (figure 25), the other, a Binabina-style canoe on Wotje Atoll (figures 26-27).[1] Reverse drift voyages from the Marshalls to the Solomons and PNG are also on record. [2]

Figure 25. A Solomon islands canoe hull washed ashore on Mile Atoll, and reused, with a make-shift outrigger, as a lagoonal fishing craft (photographed in 1991).

1 It would appear that the canoe hull belongs to a Binabina-style canoe from the central Solomon Islands (Ysabel[Isabel, Bogutu], Guadalcanal, and Gela [Nggela; Florida]). Such canoes have been described by Haddon & Hornell(1937:101) and Pule (1983). The descriptions by Pule (1983) and Hornell (1936), however, show a canoe made entirely of planks from the keelpiece up. The characteristics of the *Binabina* canoes is that the keel part is made from a dug out log, that the bow has a tapering section ending in a straight edge, that the bottom piece of the hull has cleats for braces at both bow and stern. The cleats for the seats are set into the upper planks (see Pule 1983:17). The sown-on planks of the canoe as well as the sown-on bow section are missing in the Wotje example.

2 District officer Kavieng reports arrival of a one-masted cutter in distress from Jaluit, Cutter property of Naiborgak Co, Jaluit, en route to Ebon in 1920, blown to sea, reached Gardner I. off Kavieng after 36 days of drift (Australian Archives, Record Nº AA A457/1 Item 201/48)

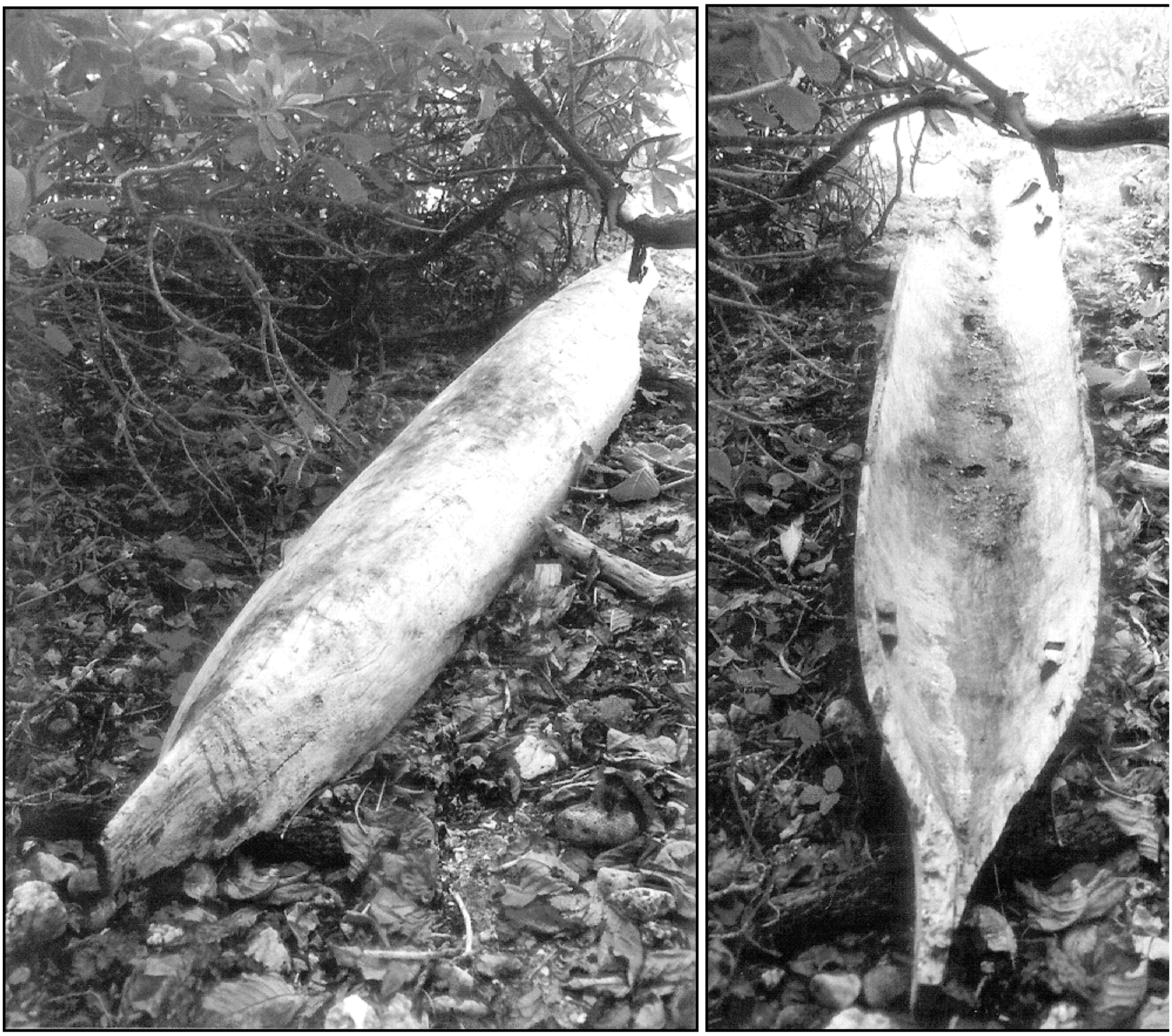

Figure 26. A Solomon Islands canoe hull washed ashore on the ocean side of Wotje Island, Wotje Atoll, photographed in 1992.

It is significant that material from the Solomon Islands not only drifts to Kiribati (Koch 1965, p. 170) but also through the doldrums to the southern Marshalls.

I-Kiribati canoes (with or without crew) were often found adrift. A sail boat hull of a modern Kiribati design drifted ashore in Mile in the late 1980s and has been refurbished since (own obs.) I-Kiribati were often stranded on the southern Marshalls, especially Arno and Mile, and these atolls have several genealogical links with the northern and central atolls of Kiribati. Shipwrecked i-Kiribati were picked up by the brig *Mercury* south of Ebon in 1858 (Hezel 1979, p. 121). In 1882 other i-Kiribati were found drifting south of Ebon by the American vessel *Northern Light* (Hezel 1979, p. 139). During the 19th century dispersed i-Kiribati were also living on Namorik (1851; Hezel 1979, p. 121; 1868; *ibid.* 127) and Jaluit (1871; *ibid.* 129; 1879 *ibid.* 136).

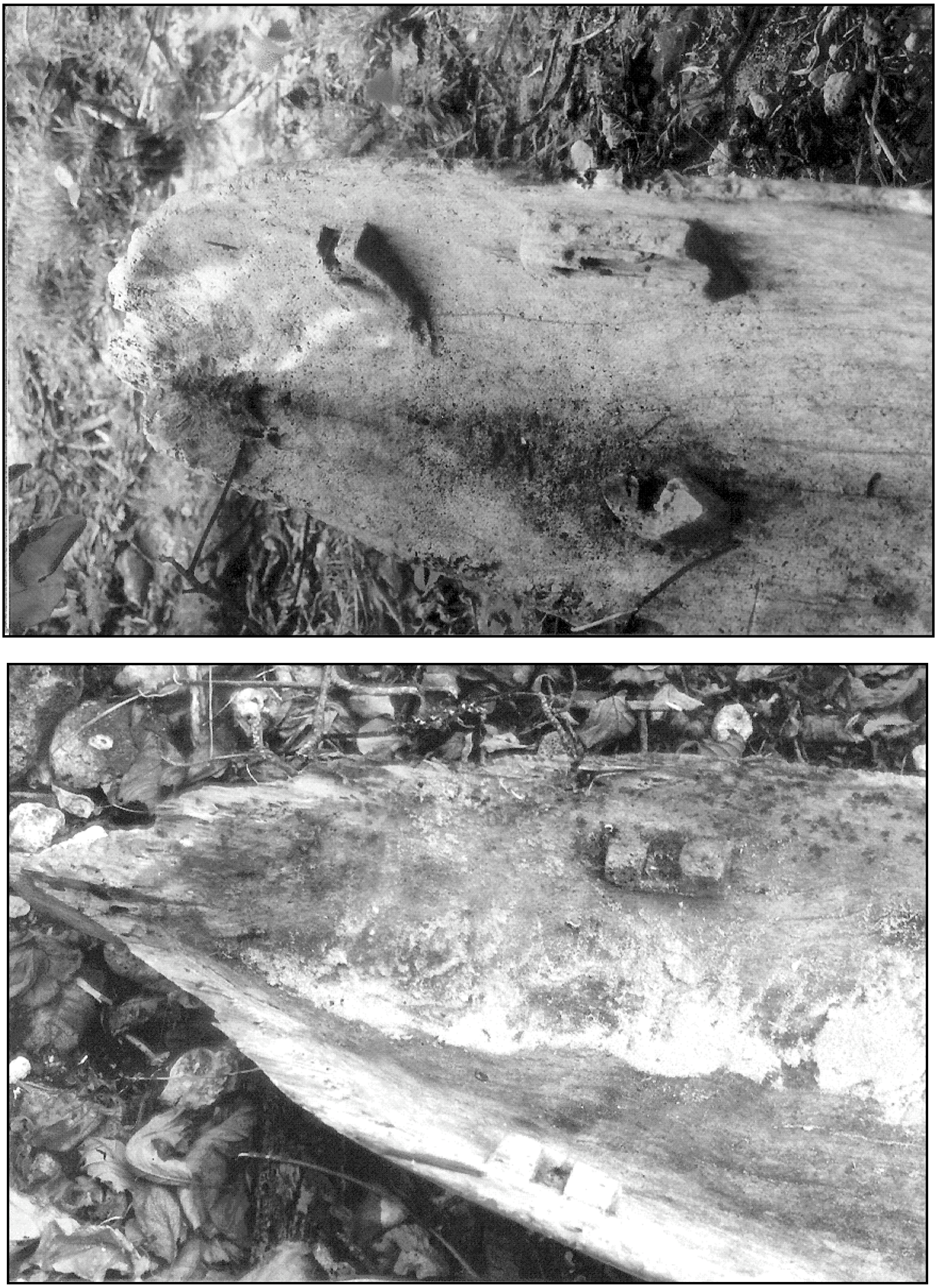

Figure 27. A Solomon islands canoe hull washed ashore on the ocean side of Wotje Island, Wotje Atoll, photographed in 1992. Top: stern; bottom: bow.

Two Catholic missionaries together with fourteen Gilbertese left Apaiang Atoll *en route* to Marakei in early September 1942. The canoe eventually wrecked on Mile Atoll in the Marshalls (Richard 1957a, p. 401). Even today, i-Kiribati fishermen occasionally drift to the shores of the southern Marshall Islands.

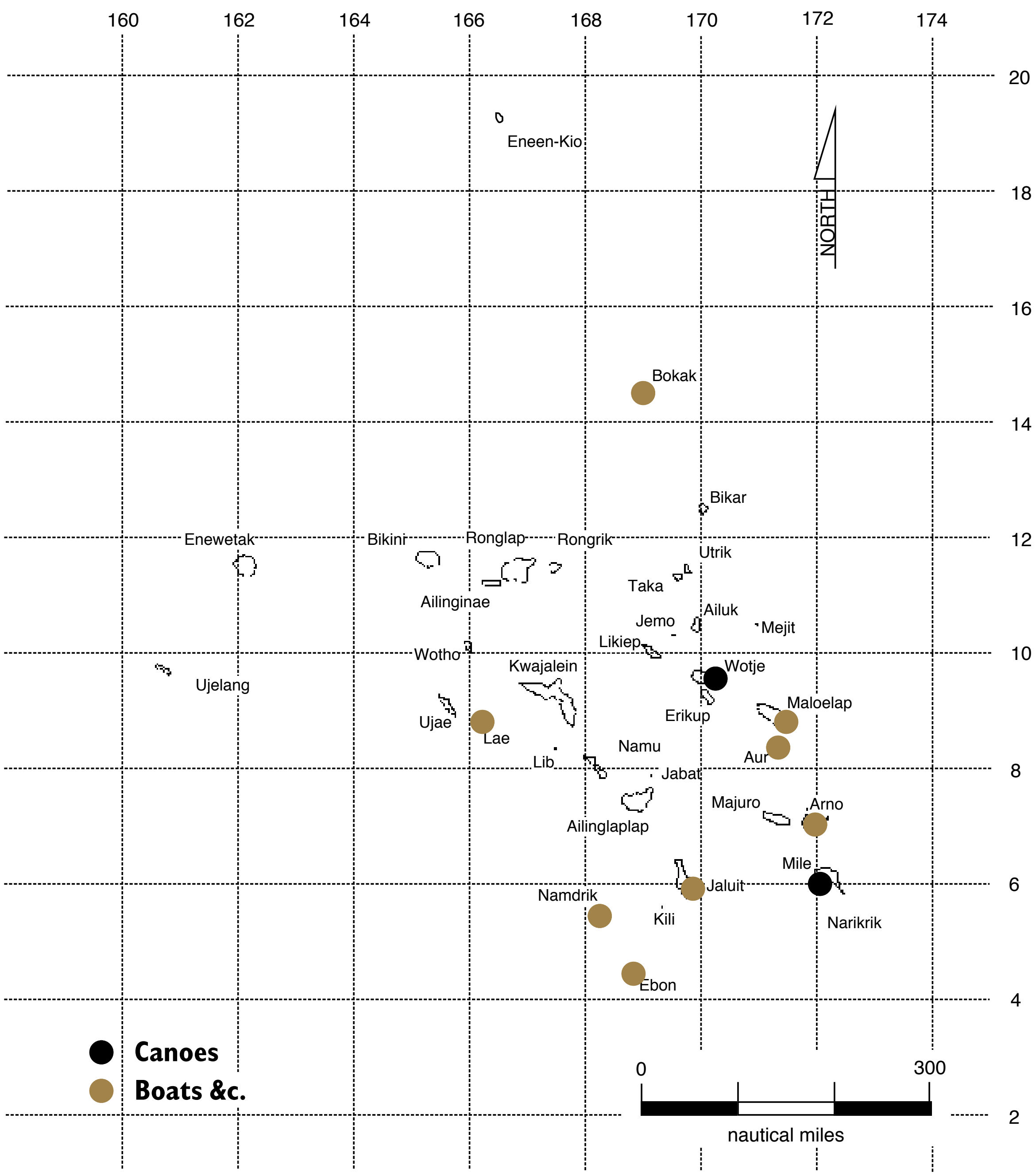

Figure 28. Map of the Marshall Isands showing the distrbution of recorded canoe strandings.

A very different example comes from Japanese PoW interrogation files captured by the US forces during WWII: On 27 May 1943 a Consolidated B-24 Liberator bomber crashed into the sea **225m NW of Palmyra Atoll** (crash site approx 8°32'N 164°20'W). The three survivors of the crew US crew drifted for 47 days in an inflatable life raft and arrived on Japanese-held Maloelap Atoll, having floated across the reef into the lagoon.[1]

A small fishing vessel went missing in 1979 off **Hana, Maui, Hawaiian Islands** and was found washed up on Bokak Atoll in 1989 (Thomas 1989, p. 33)

Drift voyages from the west are also documented: **Lamotrekese** are reported on Arno (Chamisso 1986, p. 264; Kotzebue 1812, p. II 89), **Pingelapese** arrived on Jaluit (Krämer & Nevermann 1938, p. 35) and on different occasions, **Yapese** drifted to Aur Atoll (18^{th} century, Chamisso 1986, p. 264) and Kili Island (Hezel 1979, p. 127; entry for 1868, *Bark Syringia*.). In addition canoes from **Woleai** arrived in the Marshalls (Chamisso 1986; Erdland, p. 315).

Modern drift material

The lagoonal and ocean shorelines of the islands in the southeastern parts of Mile Atoll were littered with *other drift material*: Fishing-net floats of all kinds and sizes, as well as glass and plastic bottles, and fluorescent light tubes were quite abundant. Although they were commonly concentrated in a zone reaching about 5-10m from the high tide mark of both lagoonal and ocean shore, they could be encountered up to 30m inland. This readily testifies to the degree of water washing the islands interior's can experience during storms or exceptional high tides caused as a reaction to high pressure systems in the vicinity of the atoll. The piece of pumice found on Nadikdik was in a find location among a number of large glass floats and modern plastic floats.

Another good example of extraneous objects are the Japanese glass fishing floats, many of which have been washed ashore in the atolls of the Marshall Islands. While of recent origin, they too are indicative of the ocean currents and that directions from which materials are washed to the atolls. A great amount of Japanese glass floats has been found on the west coast of the USA, washed ashore by the currents (Wood 1985).

Modern uses

While of recent origin, *glass floats* were (and still are used) as convenient water containers. The use of glass floats with a hole punched in as water storage containers is described for Bikini Atoll. This use is an adaptation of the traditional water containers, which consisted of coconut shells with one or more of the eyes drilled out (Krämer & Nevermann 1938). Today modern plastic floats are used for the same purpose (Ebon, Spennemann pers obs.; Mile, Spennemann pers obs.).

1 "Prisoner of War Interrogation Report, 6th Base Force Secret Number 330, Headquarters 6th Base Force July 1943" and 'Prisoner of War Interrogation Report Annex 23 July 1943" translation of captured Japanese document JICPOA Item 5703 captured at Kwajalein Atoll, Receievd JCPOA 11 February 1944 contained in file "Joint Intelligence Centre Pacific Ocean Areas. Translations of Japanese documents captured Makin–Kwajalein Atoll–Namur Island–Munda and Tarawa. Also primary interrogation of Japanese prisoners of war, March 1944. Record series AWM54 file 423/4/40 Part 1. Archives of the Australian War Memorial, Canberra, Australia.

Implications

The places of confirmed origin of sea rafted materials have been plotted in figure 2. It becomes evident that material from *all* areas of the Pacific (with the exception—so far—of South America and Australia proper) has arrived in the Marshall Islands and that the southern atolls are more favoured in this respect than then northern locales. Yet the current patterns are too general and do not allow micro variations, a scale that is required to make useful prediction. The distribution of the origin of sourced materials on the various Marshall Islands atolls has been plotted in figure 3. The mere perusal of the current charts would not have made likely for example the dispersal of material from the Solomons or the Bismarck Archipelago.

Table 6 Known points of origin for drift materials encountered on atolls of the Marshall Islands

Locality	Target	Item floated
Apaiang, Kiribati	Mile	canoe load of people
California, North America	Arno, Majuro, Mile, Nadikdik, Wake	cut fir logs
Central Solomons	Mile, Wotje	canoe hull
Japan		
Kiribati (general)	Ebon, Namorik	canoe load of people
Kiribati (general)	Mile	sailboat hull
Krakatau, Indonesia	Ailuk etc.	pumice
Lamotrek Atoll, FSM	Arno	canoe load of people
Maui, Hawaii	Bokak	skiff
Palmyra Atoll (225 nmNW of…)	Maloelap	rubber dinghy from crashed B-24
Phillipines (?)		bamboo
Pingelap Atoll, FSM	Jaluit	canoe load of people
Tuluman I., Bismarcks	Nadikdik	piece of pumice/obsidian
Woleai Atoll, FSM	Kili	canoe load of people
Yap, FSM	Kili, Aur	canoe load of people

In addition, there is evidence for **internal drift** in the Marshall Islands archipelago. Following the 1905 typhoon the southern atolls of Nadikdik, Mile, Arno and Jaluit, the remains of canoes, wooden bowls, houses and corpses were washed ashore on Enewetak Atoll (Jeschke 1906). Following a devastating typhoon in 1840 survivors from Mejit Island were washed ashore on Likiep Atoll (Erdland 1914, p. 18). Both cases of east to west drift, however, are well within the range of expectations given the overall current pattern.

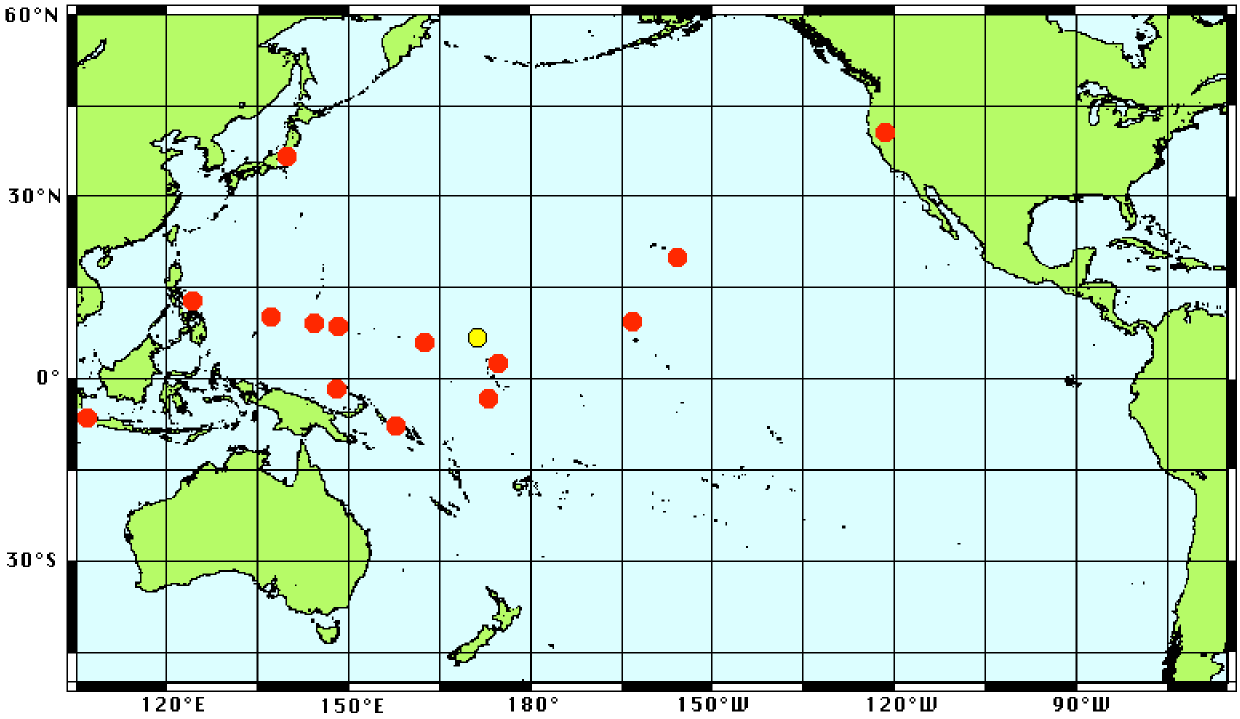

Figure 29. Map of the Pacific Ocean showing the confirmed origins of items washed ashore in the Marshall Islands.

As this small compilation has shown, there is still a need to systematically compile and draw on the historic literature and make use other contemporary material and sources. Coupled with a reassessment of the Holocene sea-level curve this observation may have a bearing on the interpretation of the distribution of mangrove species in Eastern Micronesia.

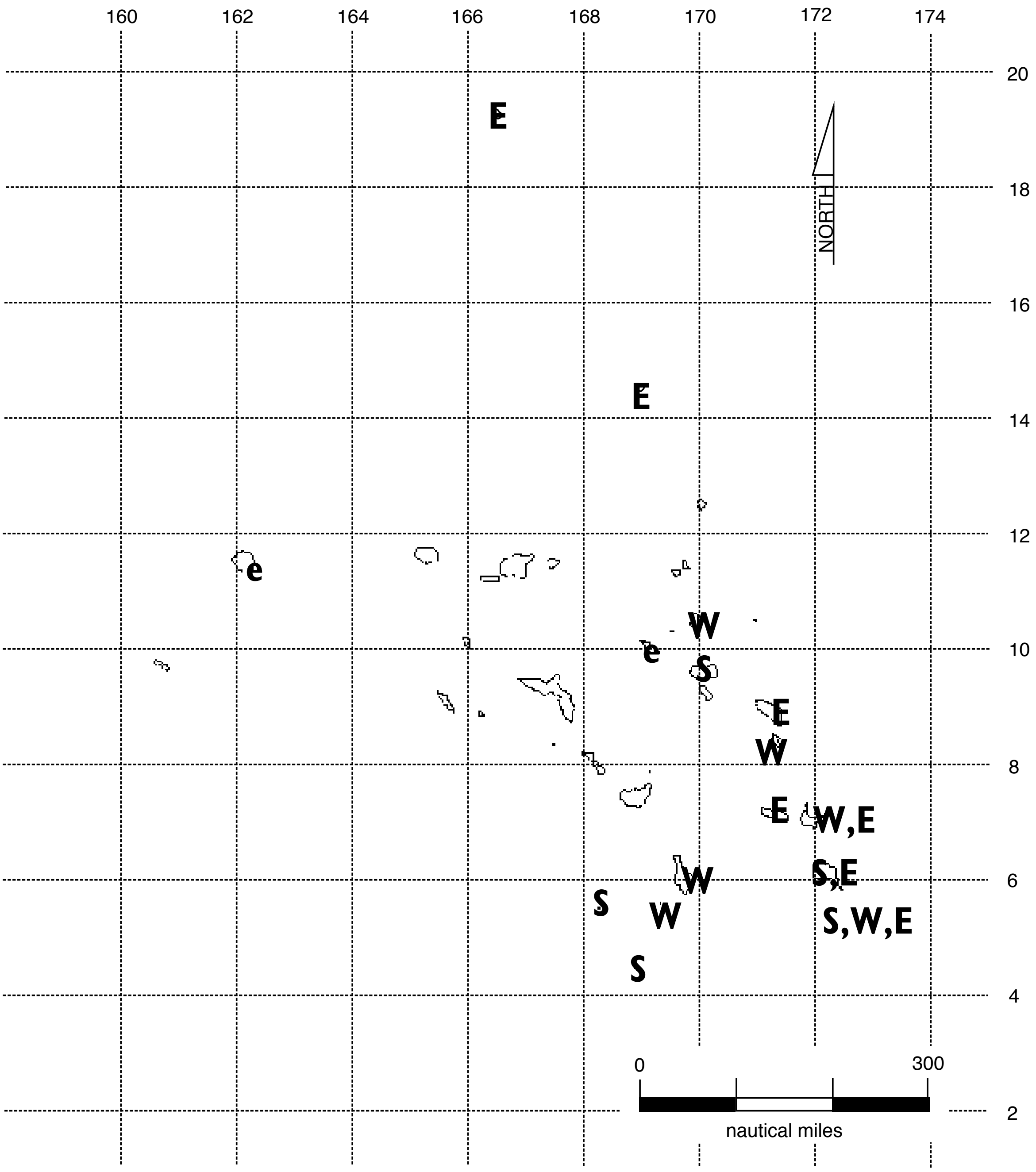

Figure 3. Map of the Marshall Islands showing the origin of drift materials encountred. Small letter designated drift within the Marshalls.

The implications of these instances of sea-borne obsidian on the interpretation of Pacific prehistory are manyfold. In the early days of Pacific Archaeology the analysis of drift voyages and drifting objects in general had attained some currency, as the notion had been advanced that the settlement of the islands had occurred accidentally (Sharp 1956; 1957). Following the ensuing discussion, this mode of settlement had been discredited (Levison *et al*. 1973; Golson 1962). In subsequent times little analysis had been done until G. Irwin took up the issue of environmentally aided settlement again (Irwin 1992).

Flakes of obsidian localised to sources largely in the Bismarck Archipelago off New Guinea have frequently been used as evidence of long-distance transport of items and ideas. Bellwood and Koon (1989) showed the presence of Talasea obsidian as far north as Borneo, and much has been made of this connection, arguing for continued cultural contact between the core Lapita area and the areas far north, the possible homeland of the Lapita people or their ancestral derivatives. Whilst the pottery of the site shows some similarity, this similarity is only general. The correlation, in fact, hinges on the dates, as well as the presence of Talasea obsidian. The amount of obsidian represented in this single float is more than the total amount of obsidian recovered from most other Lapita sites.

The issue posed by the Marshall Islands specimen is that while the presence of Talasea obsidian makes human transport from the Talasea source very likely, in fact extremely likely, it can no longer be taken for granted. While the presence of obsidian in far-flung locations is likely to imply human transport, this need not necessarily be so.

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