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SEA-RAFTED PUMICE AT MILI ATOLL, MARSHALL ISLANDS
3000km from Source

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Pumice pebbles were collected by staff of the Marshall Islands Historic Preservation Office (RMIHPO) during a 2005 cultural inventory of Jelbon Islet, Mili Atoll. GNS Science analyzed the major and trace element chemistry and found a close match with analyses of the alkali-rich rhyolite erupted in 1953-1957 from Tuluman Island, Admiralty group, Papua New Guinea some 3000 km from Mili Atoll. These findings highlight the importance of sourcing exotic raw materials in attempts to distinguish between human transport and drift by ocean currents.

Countering earlier views of Pacific Island societies as being largely isolated following initial settlement until their discovery by Europeans beginning in the early sixteenth century, the occurrence of exotic materials at archaeological sites throughout Oceania has been interpreted as evidence for trade relationships between widely dispersed communities. Long distance exchanges and inter-island population transfers are thought to have contributed to the success of the Lapita expansion into Remote Oceania more than 3,000 years ago (Galipaud, 2006; Kirch, 1988). As a result of environmental and social factors, these trade networks expanded or contracted over the centuries, but with the exception of a few insular communities, regional contacts persisted right through the historic period and the establishment of colonial governments (D'Arcy, 2006). There is little doubt that inter-island contacts remained important for many Oceanic societies, and commonly involved the exchange of goods, people, and ideas. The alternative that raw materials could disperse independently of human agency has received less attention by archaeologists despite the commonly accepted view among biogeographers that many plants and animals became established thousands of kilometers away from their point of origin as a result of natural processes, and the observation that non-organic objects can sometimes become embedded in the root system of trees.

This paper reports on pumice (an exotic light-weight volcanic rock) discovered on Mili Atoll in the Marshall Islands. Chemical analysis of samples collected from an area associated with an important cultural event in local traditions suggests that their occurrence at the site was the likely product of a natural process, i.e., drift, chronologically unrelated to the events

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described at the site. This study adds to previous efforts at disentangling natural vs. human transport of exotic materials.

THE SETTING

Mili is the southernmost, permanently inhabited atoll in the Ratak (Sunrise) Chain, located about 120 km southeast of Majuro. It ranks second in land area amongst the atolls and table reefs that comprise the Marshall Islands. The atoll is roughly triangular, consisting of 92 well-distributed islets, with a total land area of 14.94 km², surrounding a 759.85 km² lagoon (Bryan, 1971). Mili's mean annual rainfall is 4,709 mm, making it a very wet atoll (Williamson and Sabath, 1982). While the environment contributed in supporting a relatively large local population, it was by no means a stable situation. Typhoons occasionally destroyed crops and property, which in turn affected population numbers. For example, a typhoon in 1905 caused extensive damage on Mili and neighboring Nadikdik (Knox) Atoll, and several lives were lost (Spennemann and Marschner, 1994-2000).

Historical processes also contributed to demographic fluctuation. By way of illustration, during World War II, part of the atoll was bombed extensively, and the subsequent population decrease probably reflected the effects of both structural damage and vegetation destruction. At various times the population suffered from introduced diseases. With increasing contact with outsiders, a growing number of Marshallese, like many other Pacific Islanders, were exposed to diseases such as measles, gastric infections and infections of the upper respiratory tract, including influenza, for which they lacked immunity (Carroll, 1975).

EARLY SETTLEMENT HISTORY

The Marshall Islands, together with the atolls of Kiribati to the south, have produced some of the earliest dates for the human colonization of the west-central Pacific. There are at least a dozen radiocarbon ages for early cultural horizons on five different atolls and a table reef that fall within the interval AD 100-400 (Di Piazza, 1999; Riley, 1987; Shun and Athens, 1990; Weisler, 1999a, 1999b, 2000, 2001). Based on this evidence, Dickinson (2003) concluded that while mid-Holocene paleoreefs were still intertidal (until about AD 1100), habitable islets had begun to grow on atoll reefs. The apparent absence of comparable settlement in atoll groups of the South Pacific during that time may relate to the greater tidal range in the central Pacific area, allowing relict mid-Holocene paleoreef flats to project farther above low-tide level, which resulted in greater accumulation of unconsolidated sediment, at an earlier stage of sea-level decline. There are controversial dates from Bikini Atoll, the site of nuclear testing that may push back settlement to a time coinciding with the Lapita expansion into the southwest Pacific. The Bikini dates have a direct bearing on the main thrust of this paper. Because contamination of carbon samples by modern radioactivity would produce younger, not older dates (Rainbird, 2004, p. 86), it was suggested that old drift logs of long-lived species, such as those found along the west coast of North America may have been used for fuel, thus accounting for the dates' great antiquity (Kirch and Weisler, 1994). Unfortunately, it was not possible to identify the species of the dated material.

No radiocarbon dates are yet available for Mili. On the basis of dates obtained from other atolls, evidence for initial occupation could stretch back to the first centuries AD. At the time of European discovery in 1788, some of the atoll's inhabitants shared cultural ties with Kiribati. Links with Kiribati appear in Marshallese legends and stories, and *I-Kiribati* (*ri-Pit)* canoes were sometimes stranded in the southern Marshalls, especially on Arno and Mili, resulting in genealogical ties with the northern and central atolls of Kiribati (Downing *et al.*, 1992; Spennemann, 1997).

ATOLL ADAPTATION

The Marshalls, like other coral islands, presented a number of environmental challenges to the early settlers. In addition to poor soils, variation in precipitation played a significant role in limiting agricultural production. While the atolls are not generally considered to be in the typhoon belt, several devastating storms have been recorded (Spennemann and

Marschner, 1994-2000), with the further demonstration that these occurred more frequently during El Niño/Southern Oscillation phenomenon.

Annual rainfall varies considerably from north to south. In the south, Ebon (4°) receives about 5,680 mm, while at Bikini (11°30') the annual rainfall is only 1,450 mm. The marked precipitation gradient is reflected in the dominance of pandanus (*Pandanus tectorius*) and coconut (*Cocos nucifera*) tree crops in the north with an increasing reliance of breadfruit (*Artocarpus altilis* and *Artocarpus mariannensis*) and giant swamp taro (*Cyrtosperma chamissonis*), in adddition to pandanus and coconut towards the central and southern atolls.

In contrast to the terrestrial environment, marine habitats, especially in the large lagoons, provided an abundance of reef fish and invertebrates, including some 800 species of fish and over 1,000 species of shellfish (Kay and Johnson, 1987; Myers, 1991). Together these resources supplied the bulk of protein consumed by traditional Marshallese, supplemented by sea birds, eggs, and turtle meat.

Sustained contact between communities would confer advantages in the event of persistent demographic instability and chronic resource shortages in food or raw materials caused by drought or typhoon (Hunt and Graves, 1990; Williamson and Sabath, 1984). As with other atoll clusters or complexes (Alkire, 1978), populations in the Marshalls were linked by such inter-community support networks. Indeed, Pacific Islanders had developed sophisticated navigation technologies, which enabled them to cross vast ocean distances, and the Marshallese were no exception. Their unique stick charts showing current patterns within and between the Ratak and Ralik (Sunset) Chains bear testimony to their seafaring skills. Contact between groups was encouraged by differential production of foodstuff between the dry north and the wetter south, as well as being linked to tribute and warfare. Archaeological and genetic evidence also point to interactions beyond the Marshalls (Lum, 1998; Weisler, 2000; Weisler and Swindler, 2002).

PREVIOUS RESEARCH

Paul H. Rosendahl, who took part in the Kelton-Bishop Expedition to Eastern Micronesia in 1977, spent four days on Mili. He recorded two sites, identified by local informants as traditional chiefly residences on Tokewa and Nallu Islets. In addition, three test pits on Nallu yielded some midden, charcoal and burnt coral, and mostly historic period artifacts (Rosendahl, 1987).

Henrik Christiansen conducted research in 1993 as part of an Office of Territorial and International Affairs Grant to establish a record of World War II sites on Mili, Wotje, Taroa (Maloelap), and Jaluit. His report on Mili describes 174 sites, including structures, ammunition storage areas, vehicles, antiaircraft defenses, coastal defenses, aircraft hangars, airstrip and related facilities, and post-war memorial sites (Christiansen, 1994), Dirk Spennemann, then Staff Archaeologist with the Marshall Islands Historic Preservation Office (RMIHPO,) oversaw the publication of reports on the occurrence of live ammunition on Mili Islet and a Japanese bomber plane (Spennemann, 1992a; Spennemann *et al.*, 1990). In addition, he surveyed 16 islets as part of the participation in the Independent Radiological Study, but no report was published. However, his field notes include information on islet morphology, cultivars, and materials found. Spennemann also surveyed the satellite atoll of Nadikdik, where he described "coral gravel spreads" (Spennemann, 1992b). The latter survey resulted in the discovery of a pumice fragment with a chunk of obsidian adhering to it, which was traced to Tuluman Island in the Admiralty group of Papua New Guinea (Spennemann, 1997; Spennemann and Ambrose, 1997).

An underwater survey was carried out by Matthew B. Holly (Holly, 2002) and the atoll has been the focus of American and Japanese war dead recovery missions (CILHI, 2001; Katayama, 2003; Sakaue, 2004; Takenaka, 2005; Williamson, 2000).

The Alele Museum collected traditional stories on cassette tape in the mid-1980's, and produced an English-language transcript (Alele

Museum, n.d.*a*), followed by a video in the 1990's (Alele Museum, n.d.*b*).

2005 RESEARCH

From May 31 to June 14, 2005 RMIHPO, in cooperation with the Alele Museum, carried out a cultural inventory of traditional Marshallese sites on Mili. The main objective was to locate (using GPS), assess, and further describe some of the sites previously recorded by the Alele, in addition to obtaining information on other sites related to Marshallese traditions and history. Two reports on this latest research were subsequently published (Petrosian-Husa, 2005; Thomas, 2005). A total of 14 islets were investigated, resulting in the description of 30 sites.

Jelbon Islet Pumice

According to local traditions, a battle between two chiefs was fought in the interior of Mili's southernmost islet, Jelbon (0.181 km^2), in a land division (*wāto*) called Eonae. Jelbon was one of several localities where the followers of John, also known as Lutton, and Drime, also known as Bokloń waged war. The struggle took place in the second half of the 19th century between two individuals sometimes referred to as brothers or as uncle and nephew. In the ensuing struggle, John was killed, but his followers continued to oppose Drime until John's sister was finally murdered by his niece (Alele Museum, n.d.*a*; Petrosian-Husa, 2005; Thomas, 2005).

The site, of unknown dimensions, is devoid of any surface artifact or cultural feature. However, several pebble-size pumice fragments were found scattered throughout the area (figure 1). Although the atolls of the Marshall Islands are built on Cretaceous age basalt, they are entirely composed of coralline gravel, sand, or limestone. Volcanic rock does not occur *in situ* anywhere in the Marshall Islands and its discovery immediately raises questions of origin and means of transport, whether by ocean current or by canoe. Our investigation of the Mili pumice was prompted by the anthropological implication of its presence.

The site where the battle is said to have taken place and the associated pumice was designated MI-MI-JN-001 by RMIHPO (GPS coordinates: N 5°58' 10.52" E 172°07' 00.87"). The aim was to determine the precise nature of the association between the historical event and the pumice. As described by Spennemann (1997) and Vander Velde and Vander Velde (this volume), pumice and other drift material, some traced thousands of kilometers away, occasionally end up in the Marshalls. Based on ethnographic descriptions and archaeological use-wear analyses, pumice, being tougher than coral rock, was a preferred abrading material. Another application was the use of pulverized rock to fertilize nutrient-poor atoll soils (Sachet, 1955).

Figure 1. Pumice samples collected on Jelbon Islet, Mili Atoll.

Two samples, collected from the surface, were submitted to Greg Bignall and Michael Rosenberg of the Institute of Geological and Nuclear Sciences in Taupo, New Zealand for major and trace element chemistry to determine provenience (table 1). The results might in turn clarify the chronological relationship between the pumice and the battleground. As expected of drift material, the samples were well rounded, suggesting reworking by sea water. No distinctive flat use surfaces, as would be expected if the pumice had been applied to smooth relatively soft material such as bone, shell, and wood, were noted.

Common pumice types reported throughout the Pacific are those erupted from Krakatau in 1883 and more recently from submarine volcanoes in the Tonga-Kermadec arc. These were considered most likely sources

of the Mili pumice, but silica (70.3 %) and high total alkalis (Na2O=5.28 %; K2O=3.39 %) determined by whole-rock XRF, exclude both sources, and with other major oxide and trace element abundances instead point to the 1953-1957 eruptions of Tuluman Island (Reynolds *et al.*, 1980). Thus, there is no chronological association between the scattered rocks and the 19th century battle that took placed at the site. It is assumed that all pumice noted on the surface originated from this single source.

Table 1. Major and trace element abundance for Jelbon Islet, Mili whole-pumice samples, determined by x-ray fluorescence at Spectrachem Analytical Ltd (Wellington, New Zealand), for GNS Science.

	P74658	P74659
Major elements (wt. %)		
SiO_2	69.68	68.74
Al_2O_3	13.98	13.87
Fe_2O_3	3.86	3.79
MnO	0.10	0.10
MgO	0.57	0.57
CaO	1.91	1.89
Na_2O	5.23	5.10
K_2O	3.36	3.30
TiO_2	0.45	0.44
P_2O_5	0.07	0.09
LOI	0.51	1.73
Raw Total	99.72	99.62
Trace elements (mg/kg)		
As	1	<1
Ba	647	635
Ce	112	111
Cr	5	8
Cu	12	14
Ga	19	18
La	54	58
Nb	53	52
Ni	1	1
Pb	6	6
Rb	124	123
Sc	7	7
Sr	90	95
Th	9	11
U	<1	<1
V	23	22
Y	57	56
Zn	66	60
Zr	487	485

CONCLUSIONS

Although materials of various sorts could have drifted across the Pacific before making landfall, they may have been subsequently traded between islands, atolls, or local islets. The chemical analysis of pumice and other raw materials may provide both spatial and chronological baselines that could eliminate certain distributional scenarios, particularly in cases where exotic materials co-occur with other artifacts and cultural features (Thomas, 2004).

The Mili pumice was discovered several meters inland and a few meters above high water level. The morphology of the pumice is not consistent with any human modification and its inland location while possibly due to human transport, is more likely attributable to the effect of storm waves. The powerful typhoon of 1905 resulted in massive destruction by wind and flooding, but even a lesser event could have produced similar effects in view of the islets' low elevation. Dispersal of pumice rafts from the source region could have occurred within weeks to months of an eruption, or pumice could have been stranded and re-entrained any time thereafter.

In addition to modern trash, drift material reported in the Marshall Islands includes driftwood, net floats (various sources), cut logs (North America), wooden canoes (Solomon Islands), pumice (Admiralty Islands, PNG; Krakatau, Indonesia), and people in canoes (e.g., Kiribati). These multiple sources from the east, west, and south of the equator attest to the influence, interaction, and variance by season and El Niño effect, of the westward-flowing Northern Equatorial Current, eastward North Equatorial Counter-Current, and westward South Equatorial Current (Spennemann, 1997).

Jelbon does not currently support a permanent human settlement, but was the scene of intensive fighting between Japanese, Korean, and Marshallese during World War II (Petrosian-Husa, 2005). The discovery of a left human clavicle on the lagoon side of the islet raises the possibility that it could be linked to reports of a mass grave nearby. It might also be connected to the 19th century battle. Alternatively, it could part of the remains associated

with an unidentified local burial or could have drifted from other islets surrounding Mili's lagoon or from an undisclosed location beyond Mili. On a final note, a large piece of driftwood, the remnant of a tree trunk, was seen on the ocean side, which on cursory examination was reminiscent of a species found on the west coast of North America. Driftwood trees arriving from the west coast of North America (mainly California) and carried by the Northern Equatorial Current are not uncommon in the Marshall Islands (Spennemann, 1997).

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