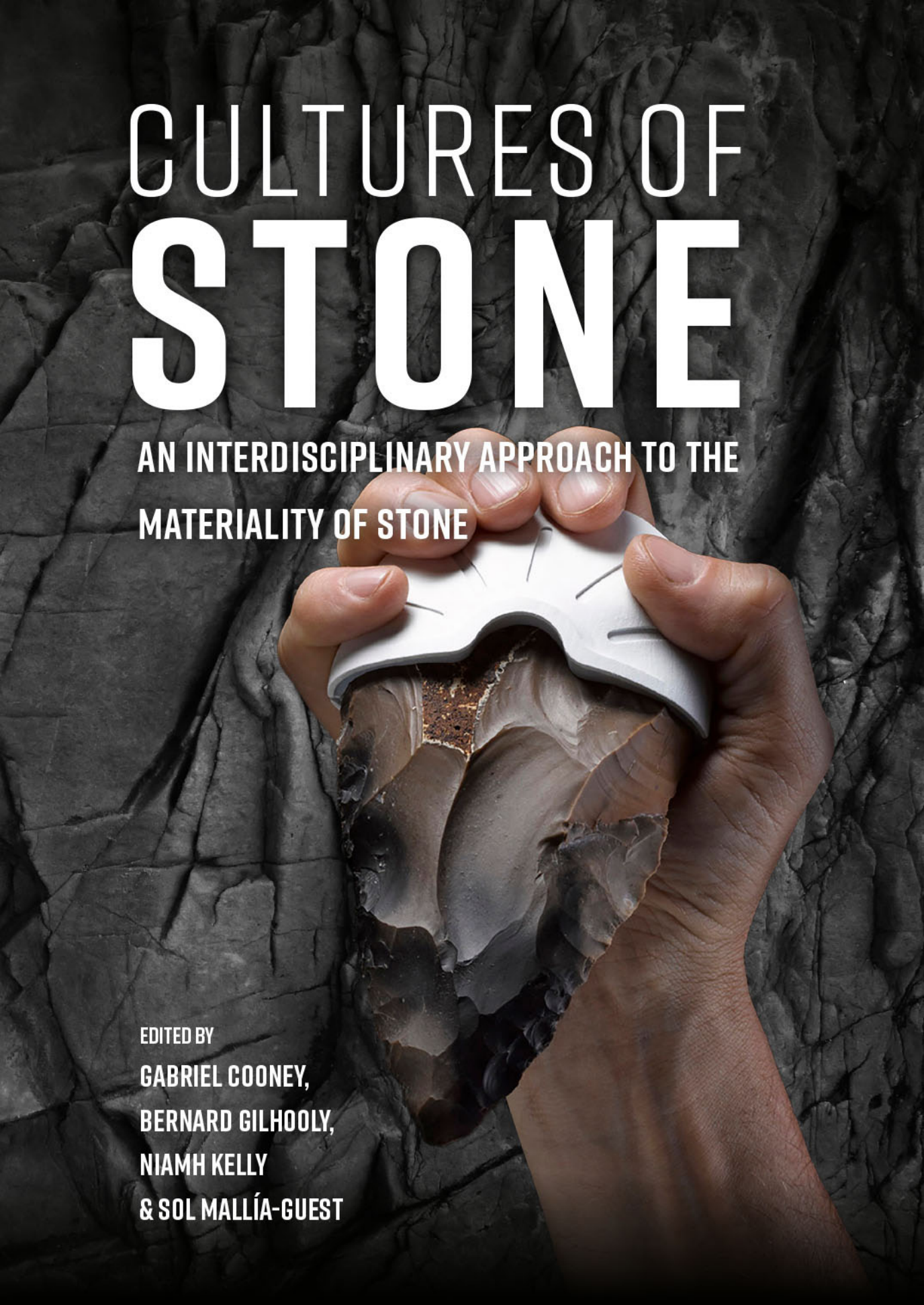
CULTURES OF STONE

AN INTERDISCIPLINARY APPROACH TO THE MATERIALITY OF STONE



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Published by Sidestone Press, Leiden
www.sidestone.com

Lay-out & cover design: Sidestone Press
Photograph cover: Experimental flint hand-axe with a 3D-printed polymer handle. MAN MADE design by Ami Drach and Dov Ganchrow (Studio Amidov,Tel-Aviv, Israel; 2014); 3D scanning: Prof. Leore Grosman (Institute of Archaeology, Hebrew University, Jerusalem, Israel); 3D printing: Stratasys and ARAN Research and Development, Israel; Photography: Moti Fishbain. Background image by Slay19 (stock.adobe.com).

ISBN 978-90-8890-891-0 (softcover)
ISBN 978-90-8890-892-7 (hardcover)
ISBN 978-90-8890-893-4 (PDF e-book)

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Yapese stone money

Local marble as a potential inspiration for producing limestone exchange valuables in Palau, Micronesia

Bosiljka Glumac, Scott M. Fitzpatrick

Abstract

Between *c.* AD 1400–1900, Yapese islanders in western Micronesia travelled to the Palauan archipelago to carve large circular or ovoid-shaped disks. Often referred to as 'stone money', they were made from a speleothem flowstone variety of limestone that formed by calcite precipitation along cave walls. These disks were an engineering marvel, and their transport to Yap by watercraft, more than 400 km away, makes them the heaviest objects ever moved over open-ocean by traditional Pacific Islanders. Thousands of pieces were brought to Yap pre- and post-European contact, and were (and still are) highly prized as important exchange valuables and symbols of cultural tradition.

One of the most fundamental questions regarding stone money is how and where it originated, given that Yap has no native sources of limestone. Palau and Yap are part of an intra-oceanic island-arc-trench system that separates the Pacific and Philippine plates. Yap is unusual in that it is mainly composed of metamorphic, not volcanic rocks. Yap also lacks uplifted limestone terrains common in the neighbouring archipelagos (*e.g.* Palau and the Marianas).

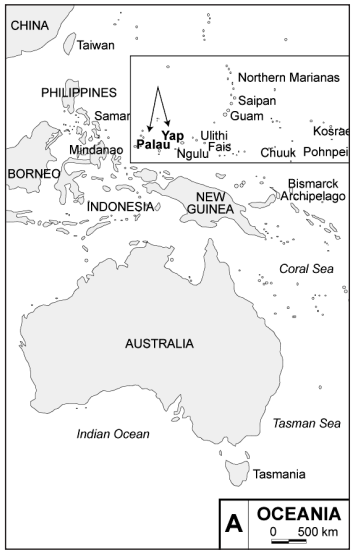
To address these questions, we examined the occurrence of rare, small, and lichen-covered outcrops of calcitic marble (metamorphosed limestone) on Yap. While there are no definitive records of Yapese stone money being produced from marble, this study documents an attempt to carve a disk from this material. We suggest that the white colour, crystalline texture, and shiny lustre of marble may have initially inspired the Yapese to seek similar material elsewhere. The discovery of abundant flowstone with similar composition and appearance on Palau, may have been the impetus for why this exchange system began. Even though the surface of most stone money on Yap is now darkened due to weathering, this would not have diminished its overall value, which is based on numerous other variables such as its pedigree, and not on visual appearance.

Keywords: currency, trade, Caroline Islands, Pacific.

in: G. Cooney, B. Gilhooly, N. Kelly and S. Mallía-Guest (eds) 2020: Cultures of Stone: An Interdisciplinary Approach to the Materiality of Stone. Leiden: Sidestone Press, pp. 65–78.

Introduction

At European contact, peoples on Yap, a small island group in western Micronesia (Figure 1), were observed displaying large stone disks, which they referred to as *rai*, but that are commonly known today as 'stone money' (Gillilland 1975; Fitzpatrick 2003a; 2008; 2016). These circular or ovoid shaped pieces of stone, typically perforated with a hole through the centre, were described to Europeans by the Yapese as having been quarried in the Palauan archipelago about 450 km (280 miles) away (Figure 1) and then brought back to Yap by raft or canoe (Hazell and Fitzpatrick 2006). During the Japanese administration in the 1930s, more than 13,000 pieces of stone money were recorded. While many were destroyed during various colonial administrations for use as anchors and construction material, or became broken or lost over time, there are still thousands of pieces found on Yap today.



On Yap, affectionately known as the 'Island of Stone Money', these disks are commonly displayed along roads, village pathways, and in front of family homes and traditional meeting houses (Figure 2). The surfaces of most *rai* are darkened due to weathering and heavy lichen and moss covering, so it is often difficult to see the true colour and composition of the stone that lies underneath. Macroscopic examination of clean examples indicates that they are made from a speleothem flowstone variety of

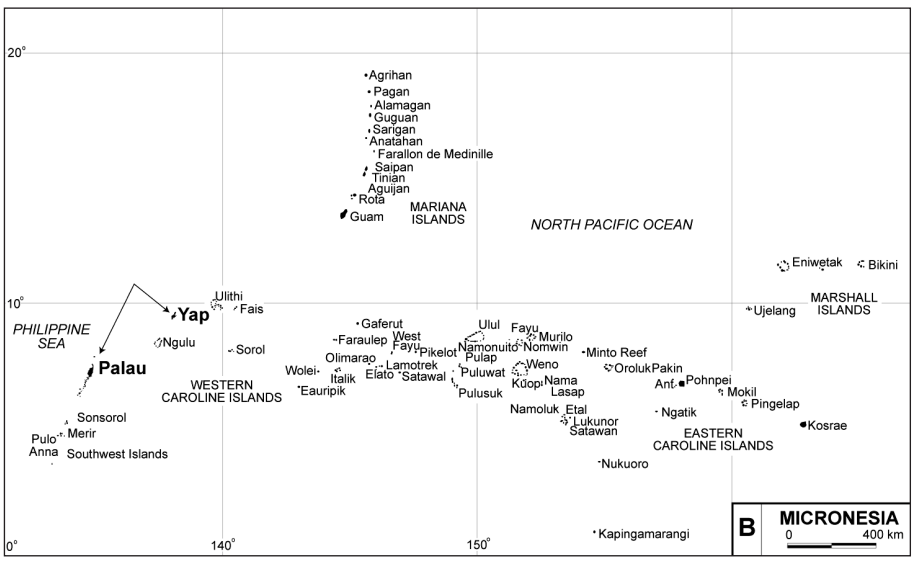


Figure 1. Location of Yap (Federated States of Micronesia) and the Republic of Palau in Oceania (A) and Micronesia (box in A, enlarged in B). Note the distance between Yap and Palau of more than 400 km (250 miles).

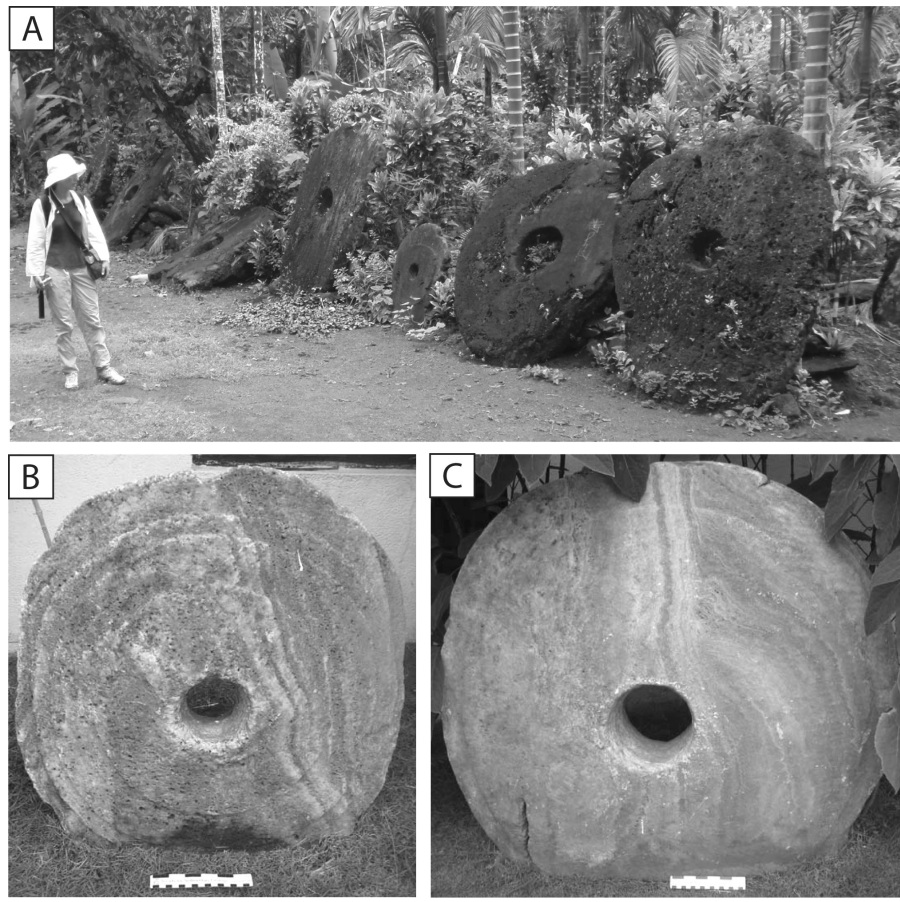


Figure 2. Appearance of stone money on Yap. A) Stone money lining a village pathway. Note its characteristic size and shape, and the darkened (lichen and moss covered) exterior. B) and C) Two examples of 'clean' stone money (displayed at a local hotel) showing the characteristic colour and texture of the limestone, of the cave flowstone variety, from which the stone money was made. Scale in centimetres and inches.

limestone, that forms by calcite precipitation along cave walls (Figure 2B and C). Calcitic composition has been confirmed by X-ray diffraction (XRD) analysis of both stone money found in Palau and associated manufacturing debris (Fitzpatrick 2003b). This limestone is commonly light in colour, laminated or banded, with a shiny lustre due to its typically coarse crystalline texture of large calcite crystals.

Due to the absence of limestone caves on Yap, the Yapese had to travel elsewhere (primarily, or even exclusively) to the Palauan archipelago, between perhaps *c.* AD 1400–1900, to carve stone money in limestone caves (Figure 3; Fitzpatrick 2003a). The carving of these disks using pre-contact stone and shell tools and movement from both inland and coastal quarries in Palau across rugged karst terrain and shallow reef systems was an engineering marvel, while their transport to Yap, hundreds of kilometres away, makes them the heaviest objects ever moved over open ocean by traditional Pacific islanders (Fitzpatrick 2003a; Hazell and Fitzpatrick 2006). The production and transportation continued post-European contact, using metal tools and ships

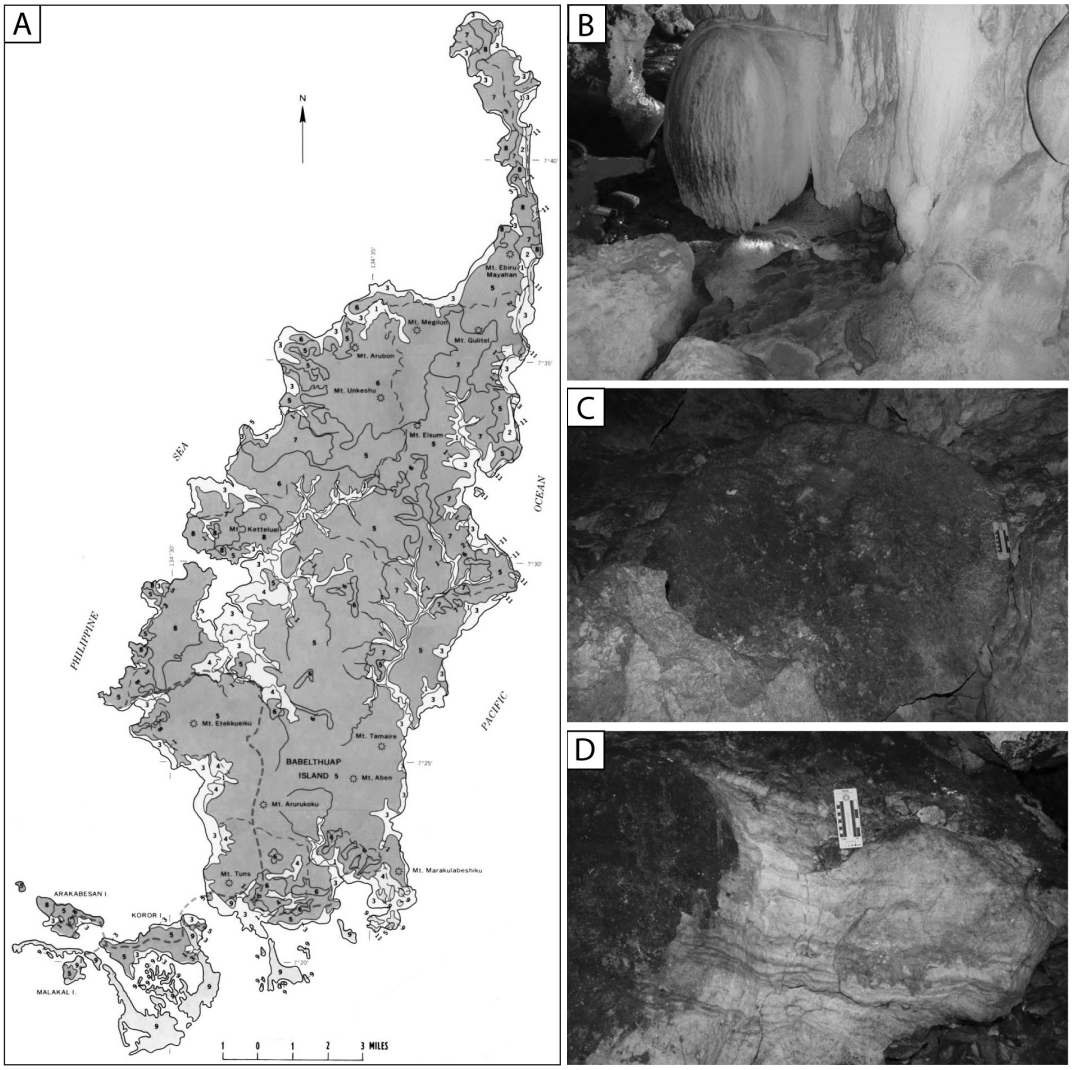


Figure 3. Geology and caves on Palau.

A) Soil map of Palau showing the dominance of soils developed on volcanic rocks (numbers 5–8) and the presence of soils developed on limestone (number 9) in the southernmost Rock Island area. Numbers 1–4 represent soils developed on valley floors and marine terraces, and number 11 indicates soils formed on coral sand. Note an older spelling for Babeldaob Island (i.e. Babelthuap),(General Soil Map, Islands of Palau 1983).

B) Interior of a cave on Palau developed in the limestone terrain on the Rock Islands. Note the thick speleothem precipitates of the flowstone variety along the cave walls. Person for scale in the central left.

C) An example of abandoned Yapese stone money inside a cave on Palau. Note its characteristic round shape and dark patina. Scale in centimetres and inches.

D) Fresh in situ exposure of cave flowstone showing its characteristic light colour and banded texture, which is identical to that of stone money (see Figures 2B and C). Scale in centimetres and inches.

(LeHunte 1883; Furness 1910; Matsumura 1918; Berg 1992; Gillilland 1975; *e.g.* starting in 1874 by an Irish sea captain named David O'Keefe).

On Yap, stone money are highly prized as important exchange valuables and symbols of cultural tradition (Einzig 1966; Gillilland 1975; Fitzpatrick 2003a). Stone money are used in many different social transactions, including births, name giving ceremonies, adoption, marriage, securing allies, ransom of a corpse, loan or promise, and purchase of goods or services. The value of a piece of stone money is based not only on its size, shape, and quality, but also the process by which it was acquired, including by whom, when and how it was made on Palau and brought to Yap, and what the risks and casualties were, as recorded in the oral history of individual objects (Einzig 1966; de Beauclair 1971). The pedigree of each *rai*, per se, was paramount in the determination of its value.

With this in mind, our primary research questions are:

- How did Yapese stone money originate?
- What may have inspired or served as the impetus for the Yapese to begin producing these limestone exchange valuables in Palau?
- Why would the Yapese travel to Palau to carve stone money and transport them to Yap?

To address some of these questions, we discuss the unique geological environments of Palau and Yap and relate geological origins of these Pacific islands to the distribution of stone resources and their availability and utilisation. We document an attempt to carve stone money on Yap from local marble and hypothesize that the textural and compositional similarity between marble and speleothem flowstone may have inspired the Yapese to carve stone money in the limestone caves found primarily in the Rock Islands of Palau (Figure 3A).

Geological setting and stone resources

The Republic of Palau

Palau is one of the typical intra-oceanic island-arc-trench system islands in the western Pacific composed mainly of volcanic rocks (Figure 3A; Rytuba and Miller 1990). The main archipelago stretches for about 150 km from Kayangel, an atoll in the north, to the southernmost island of Angaur in the south. The southern portion of the archipelago consists of an uplifted limestone terrain of Tertiary age, comprising several hundred, mostly uninhabited limestone islands, known locally as the 'Rock Islands'. They feature prominent bioerosional notches, shear limestone cliffs, small beaches, and densely vegetated interiors (Figure 3A). Geologically, the Tertiary limestone that makes up the islands is of shallow water origin and mainly composed of small to very large shell pieces in a muddy and sandy matrix. This sediment is analogous to that forming within the shallow lagoon and coral reefs that surround the archipelago today. The larger islands toward the north (Koror and Babeldaob), are primarily of volcanic composition, with the latter having extensive fringing reefs (Figure 3A).

The wet and humid climate of Palau, in conjunction with dense vegetation, results in extensive dissolution of exposed limestone and the formation of numerous

caves, rock shelters, overhangs, steep, jagged valleys, and other features typical of a karst terrain (Mylroie and Carew 1995; 1997). Inside the caves are very extensive and thick precipitates, or speleothems (Figure 3B). Of particular interest are speleothems that form thick coatings on cave walls called flowstone, because these were primarily used as the *in-situ* source material for the carving of Yapese stone money (Fitzpatrick 2003b). It is not uncommon to find unfinished or abandoned examples in or around quarry sites on Palau (Figure 3C).

Examination of cave flowstone confirms that this was the preferred source material for stone money: the light colour of fresh stone, its laminated structure, and the shiny texture deriving from coarse crystalline texture of large calcite crystals (Figure 3D) are identical to the material from which stone money was manufactured (Figure 2). Limestone bedrock, on the other hand, was never used to carve stone money on Palau, due to its highly heterogeneous and commonly very porous and friable texture, with loosely embedded shell material of a variety of sizes and shapes. Dissolution of marine limestone bedrock and its re-precipitation as thick cave flowstone, however, created a much more suitable stone carving medium, with more homogeneous and compact texture of interlocking calcite crystals. The relative softness of calcite allowed this special type of terrestrial limestone (cave flowstone variety) to be carved using traditional stone and shell tools (Fitzpatrick 2003b; 2016).

Yap, Federated States of Micronesia

Like Palau, the Yap islands are also part of an intra-oceanic island-arc-trench system formed by westward subduction of the Pacific plate underneath the Philippine plates (Figure 4). Yap is unusual, however, in that on the Pacific plate to the east of the islands, there is a large area of very thick oceanic crust with many seamounts and atolls, known as the Caroline Ridge (Figure 4). The existence of this ridge makes subduction underneath Yap very difficult (Rytuba and Miller 1990) and explains the origin of Yap and its unusual geology (Hawkins and Batiza 1977). Yap formed as a typical volcanic arc-trench system in the early Tertiary by westward subduction of the Pacific sea floor (Figure 4B-I). Blocking of the subduction zone by the Caroline Ridge, however, ended volcanism and caused the deformation, uplift, and over-thrusting of the sea floor from the west of Yap, over the former volcanic arc (Figure 4B-II). This process caused extensive metamorphism and instead of typical volcanic rocks, Yap is today composed mainly of metamorphic rocks (Figure 4B-III). Flat slabs of schist, for example, are commonly used to pave village paths on Yap (Hunter-Anderson 1983).

Unlike Palau and many other Pacific islands (*e.g.* Guam; Figure 4A), Yap does not have an uplifted limestone terrain (Nedachi *et al.* 2001). Such a terrain was never present or has been completely eroded away (Hawkins and Batiza 1977). Limestone of either shallow marine (atoll reefs and lagoons) or deep marine (planktonic ooze) origin was likely present around the incipient volcanic islands of Yap (Figure 4A-I). The process of metamorphism resulted in recrystallization of limestone into marble. Rare and small exposures of marble on Yap are part of the Map Formation of Miocene age (Figure 5; Johnson *et al.* 1960; Hawkins and Batiza 1977).

This formation is a polymict tectonic breccia (*i.e.* rock with large angular clasts of multiple composition) that formed along thrust faults during tectonic deformation and metamorphism of Yap (Figure 4B-II; Hawkins and Batiza 1977). It had been pre-

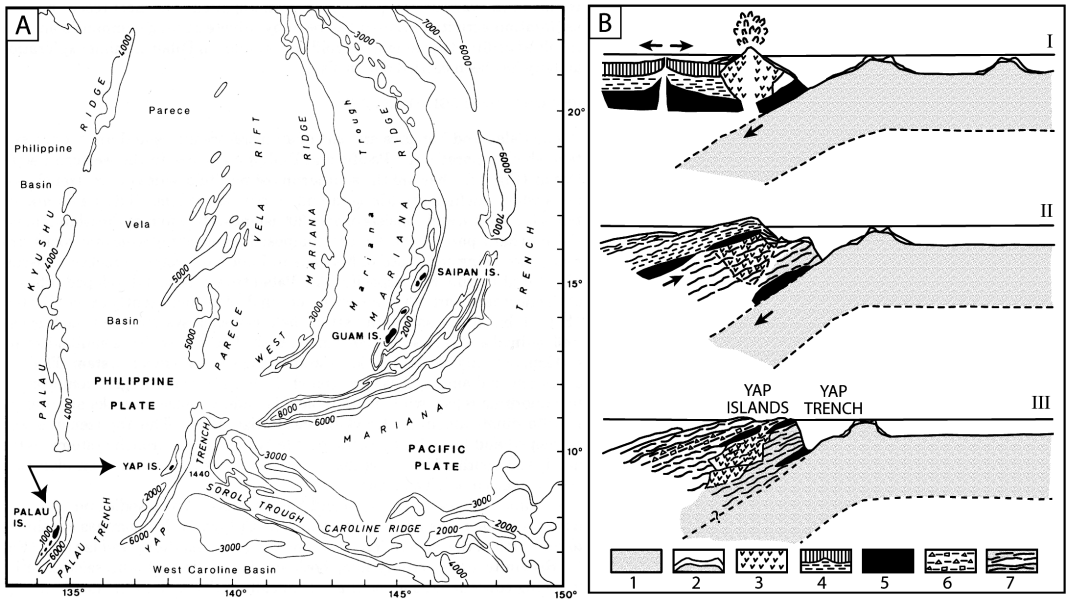


Figure 4. Geology of Yap.

A) Both Yap and Palau (arrows) are part of an intra-oceanic island-arc-trench system that separates the Pacific and Philippine plates in the western Pacific. Note the presence of an area with thick oceanic crust with numerous seamounts and atolls known as the Caroline Ridge to the east of Yap (Rytuba and Miller 1990).

B) Three stages in the formation of Yap (Hawkins and Batiza 1977). I) Formation of Yap as a typical volcanic arc-trench system in the early Tertiary by westward subduction of the Pacific sea floor. II) Cessation of volcanism due to blocking of the subduction zone by the Caroline Ridge, causing the deformation, uplift and over-thrusting of the sea floor from the west of Yap, over the former volcanic arc. This process caused extensive metamorphism and instead of typical volcanic rocks Yap is now composed mainly of metamorphic rocks. The Map Formation is a tectonic breccia that formed along the thrust faults. Blocks of marble within the Map Formation are metamorphosed limestone of either shallow (atoll reefs and lagoons) or deep marine (planktonic ooze) origin. III) Present-day schematic geologic cross section of Yap showing the dominance of metamorphosed igneous rocks and the distribution of the Map Formation breccia and intercalated marble. The island does not have an uplifted Tertiary limestone terrain that is common in nearby islands (e.g. Palau and Guam). Such a terrain was never present or has been completely eroded away. Key: 1=oceanic crust, 2=carbonate rocks of reefs, 3=volcanic-plutonic material of arc, 4=oceanic crust and upper mantle of marginal sea, 5=ultramafic rocks, 6=Map Formation breccia, 7=marble incorporated in metamorphosed equivalents of Unit 1.

viously described as breccia and conglomerate (*i.e.* rock with large round clasts) with fragments of metamorphic (hornblendite, hornblende schist, some greenschist, and minor amounts of serpentinite) and igneous (ultrabasic and volcanic) rocks, ranging in size from fine gravel to blocks about 2.5 m (8 ft) in diameter, embedded in a fine sandy or silty matrix (Johnson *et al.* 1960). Hawkins and Batiza (1977) noted the dominance of metamorphosed igneous rocks and the distribution of the Map Formation breccia with marble blocks on Yap (Figure 4B-III). These blocks of marble are now extremely rare on Yap, and we explore their possible role as an inspiration for stone money.

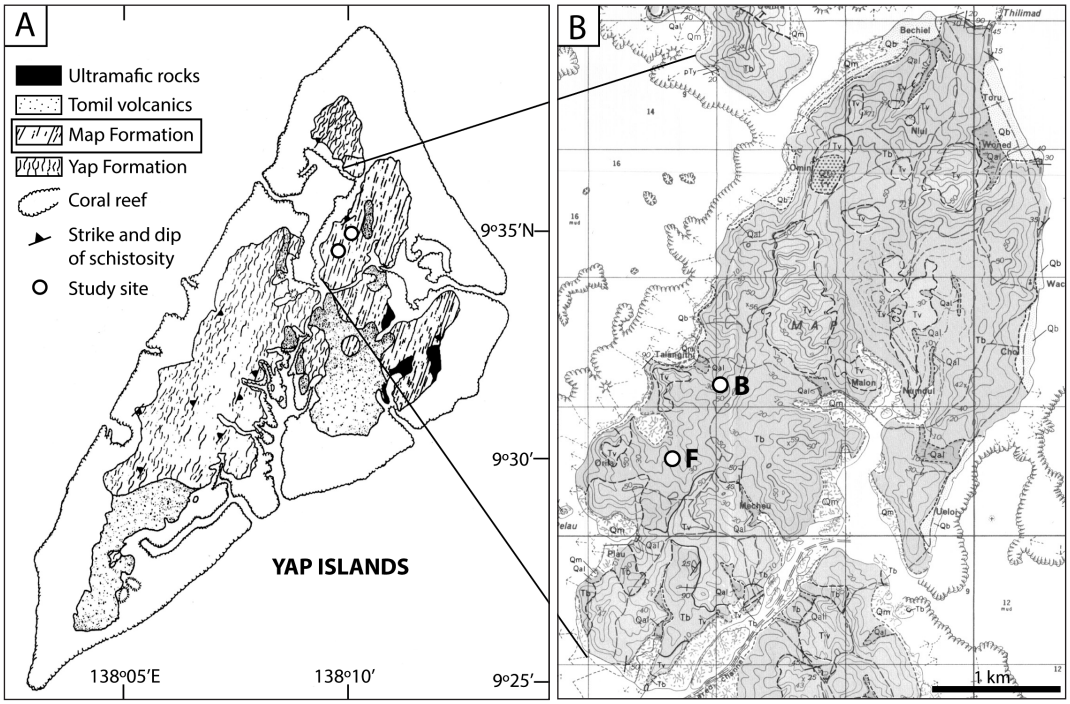


Figure 5. Locality map of marble exposure study sites on Yap.

A) Simplified geologic map of Yap (Hawkins and Batiza 1977, based on Johnson et al. 1960). White circles denote the two marble localities examined in this study. Note that marble belongs to the Map Formation.

B) Detailed geologic map of the study area showing the Blapachee (B) and Fadrik (F) marble exposures within the Map Formation of Miocene age (Johnson et al. 1960). The map shows that Yap is mainly composed of the Map Formation (Tb) and the Tomil volcanics (Tv), both of Miocene (Tertiary) age. Marble is rare and was not even mentioned in the accompanying description of the various rock types found as fragments in the Map Formation breccia and conglomerate.

Local marble as an inspiration for Yapese stone money?

On Yap, we examined two lichen-covered, boulder-size outcrops of marble, named the Blapachee and Fadrik sites (Figure 5 and 6). Cut and polished samples from these outcrops reveal the white colour, shiny lustre, and coarse crystalline texture typical of marble (Figure 6C and D). Examination of petrographic thin sections of these samples, under a polarized microscope, showed the characteristic texture of large, interlocking calcite crystals (Figure 6E and F).

Observations at the Blapachee outcrop are especially significant as the site contains a partially carved stone money disk (Figure 6B). Unfortunately, we do not know who attempted and abandoned carving at this site, or its temporality. The carvings have the same patination as the surface of the surrounding rock outcrop, suggesting that the carving is not modern (Figure 6B).

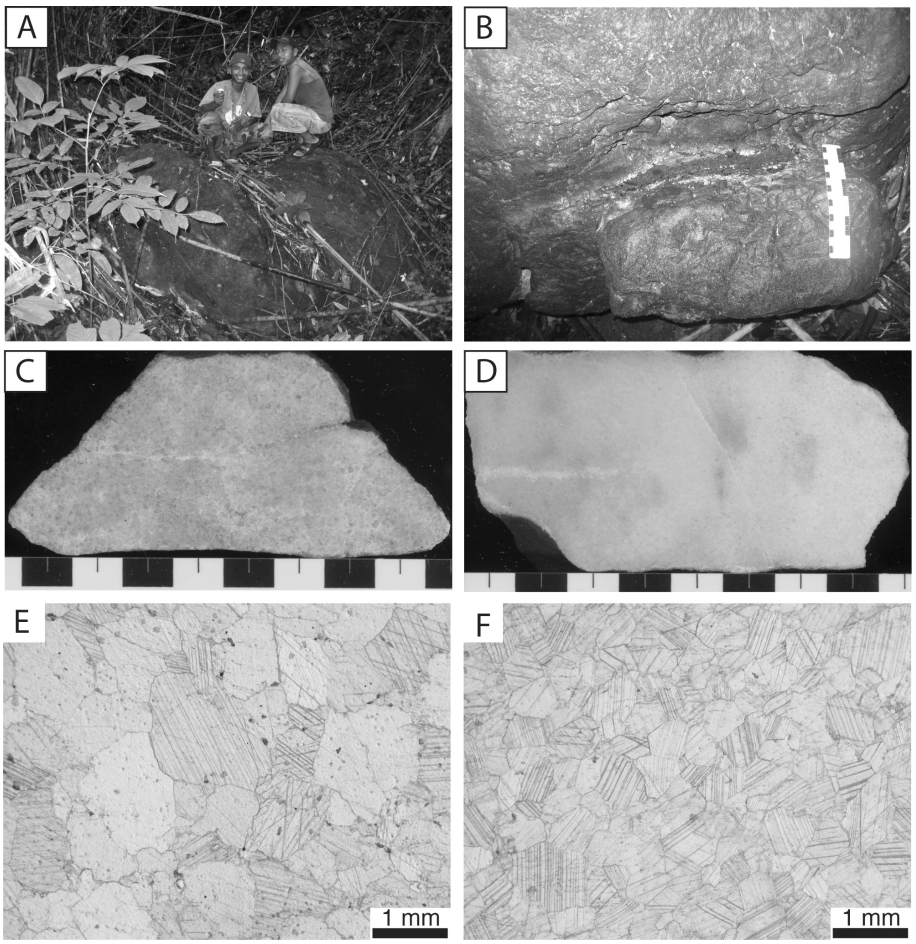


Figure 6. Observations at the Fadrik and Blapachee sites on Yap.

A) Field photograph of the Fadrik site showing the characteristic small size and boulder shape of rare, poorly exposed, and completely moss and lichen covered marble outcrops.

B) Field photograph of similar marble outcrop at the Blapachee site where we discovered a partially carved stone money shown in the lower portion of the photograph taken in planar view. Note the characteristic round shape of stone money and the very similar patination pattern of the carving and the surrounding rock surfaces. Scale in centimetres and inches.

C) and D) Cut and polished samples from the Fadrik and Blapachee sites, respectively, showing the characteristic light colour and coarse-crystalline texture of marble. Scale in centimetres.

E) and F) Photomicrographs of petrographic thin sections made from Fadrik and Blapachee samples, respectively, taken in plane polarized light, and showing the characteristic texture of marble with coarse, interlocking calcite crystals.

There are no definitive records of Yapese stone money being produced from marble (*e.g.* Einzig 1966; Gillilland 1975; Fitzpatrick 2003a). However, the Yap Historical Preservation Office staff recalls an oral tradition of a stone money disk that was referred to as the 'no tears' *rai,* because nobody was injured or died in the process of its acquisition; it was made locally on Yap by a person whose attempt at travelling to Palau was interrupted by a storm (personal communication, 2009). Perry (1979) also reports a piece of stone money on Yap that was named 'Without Tears', because no one died in its manufacture or transport. '*When compared to "tearful" rai–stones of broken bones, spilled blood and violent death–its value was diminished*' (Perry 1979). The details of this story or the whereabouts of this *rai* are unknown.

All of the exposed rocks on Yap are metamorphic and igneous, of relatively dark and dull appearance. Marble, in striking contrast, appears white and shiny. It is possible, therefore, that the occurrence of marble on Yap represented a very rare and precious stone resource, for people to utilize and turn into objects of special value. We suggest that the white colour, crystalline texture, and shiny lustre of relatively rare calcitic marble, may have inspired Yapese islanders to seek similar material elsewhere, after having perhaps already seen or heard of similar material in the limestone caves of Palau.

Limestone and marble are both composed of the carbonate mineral calcite ($CaCO_3$) and are relatively soft carving media. Geologically, limestone is a sedimentary rock that forms by precipitation of calcite from water and by accumulation and lithification (*i.e.* cementation) of shells and skeletons of carbonate secreting organisms. Recrystallization of limestone, under elevated temperature and pressure during burial, leads to its metamorphism into marble. This process destroys the primary texture of the limestone and produces the homogenous network of interlocking calcite crystals characteristic of marble (Figure 6).

Although limestone comes in many different varieties, the cave flowstones that form by precipitation of calcite, from water flowing along cave walls, are similar to marble, in terms of their texture and appearance: they are both light in colour and have a shiny lustre due to the presence of coarse calcite crystals. When stone money was originally carved and brought to Yap it was also white and shiny, but soon afterwards became darkened, due to weathering and colonization by lichen and moss in the warm and humid tropical climate, as noted previously at Blapachee outcrop (Figure 2). It seems, however, that this change did not alter the perception of its value, which is based in part on its pedigree, which in turn, is based on oral traditions of how each piece was acquired and owned, not simply on its visual appearance (Gillilland 1975; Fitzpatrick 2003a; 2008).

The distribution of marble *vs.* limestone on the islands in the western Pacific is controlled by unique geological and plate tectonic history of individual islands. Yap is geologically different from other islands in that it is mainly composed of metamorphic rocks, including rare marble, and not the typical volcanic rocks found elsewhere in the region (Figure 5). Yap also lacks uplifted Tertiary limestone terrains, which are common on many other nearby islands, such as the Rock Islands in the southern Palauan archipelago and some of the Marianas (*e.g.* Guam, Saipan) (Figure 3). Nedachi *et al.* (2001) related the lack of limestone on Yap to the culture of stone money.

We suggest that the dissolution and reprecipitation of limestone, in the form of flowstone in caves on Palau, produced a stone resource of special importance to the Yapese, possibly because of its resemblance to marble. While we hypothesise that the marble on Yap may have been the impetus to begin carving stone money, we must emphasise that cur-

rently there is no available information to anchor these events chronologically. The timing of the documented attempt at carving stone money from the marble on Yap (Figure 6B) is not known. It is possible that such attempts were also made during the active stone money exchange, as suggested by the account of the 'no tears' *rai*, and/or after the exchange began to decline. In any case, this study demonstrates an example of the relationship between geology and the distribution of stone resources, which in turn may have had a profound influence on the extensive, but highly unusual utilisation of limestone from Palau, for carving large megalithic objects for use in exchange by Yapese islanders.

Conclusions

Thousands of disk-shaped stone artefacts, commonly referred to as stone money, were brought to the western Pacific island of Yap in Micronesia pre- and post-European contact (between *c.* AD 1400–1900). They were (and still are) highly prized as important exchange valuables and symbols of cultural tradition. This study seeks to understand the reasons why and how this stone exchange system began. Here we documented an undated attempt to carve a disk from a small, lichen-covered outcrop of marble (metamorphosed limestone) on Yap. While there are no definitive records of Yapese stone money being produced from marble, we suggest that the white colour, crystalline texture, and shiny lustre of relatively rare calcitic local marble, may have inspired Yapese islanders to seek similar material elsewhere. The discovery of abundant limestone of the flowstone variety, with similar composition and appearance to marble, in caves of the Palauan archipelago, about 450 km (280 miles) from Yap, may have been the impetus for this limestone exchange. Future research will examine various pieces of stone money geochemically and mineralogically to discern whether the provenance of these objects can be sufficiently determined, to help answer further questions regarding this unique stone exchange system.

Acknowledgements

A Rappaport Fellowship and Kahn Liberal Arts Institute Grant from Smith College provided financial support for BG's fieldwork. SMF's research was funded in part by the National Science Foundation (BCS-0001531), Sigma Xi, and the Sasakawa Peace Foundation. The Koror State Government Office is thanked for the permission to conduct fieldwork on Palau. Pat and Lori Colin (Coral Reef Research Foundation) were instrumental for executing the fieldwork on Palau, and the Yap Historical Preservation Office Staff oversaw local fieldwork. Tony Caldanaro (Smith College) assisted with fieldwork and making petrographic thin sections. We are especially thankful to the 'Cultures of Stone' conference organizers for the opportunity to present this work.

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