Linking the Artifact to the Activity: Tarring Pebble Classification and Use of Asphaltum on San Nicolas Island, Alta California

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Abstract Tarring pebbles have been used by Native Americans of southern California for thousands of years to melt, apply, and spread asphaltum. Although tarring pebbles are frequently observed in the archaeological record, they are seldom analyzed. In this study, we use size to construct a classification and typology of tarring pebbles found at three archaeological sites on San Nicolas Island, California. Three separate tarring pebble clusters exhibit particular characteristics that are distinct from one another. Our research suggests that tarring pebbles with specific attributes were being targeted for distinct purposes, allowing us to construct a classification based on pebble size.

Resumen Los guijarros para alquitranar han sido usados por los indígenas de la parte sur de California durante miles de años para derretir, aplicar, y extender el asfalto. Aunque los guijarros para alquitranar se observan con frecuencia en el registro arqueológico, rara vez se analizan. En este estudio, usamos el tamaño para construir una clasificación y una tipología de estos guijarros encontrados en tres sitios arqueológicos en la Isla de San Nicolás, California. Tres grupos separados de guijarros para alquitranar presentan características particulares que son distintas el uno del otro. Nuestra investigación sugiere que los guijarros con atributos específicos se dirigieran a los objetivos distintos, permitiéndonos elaborar una clasificación basada en el tamaño de guijarro.

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> *The process of lining them [water bottles] was rather ingenious. She [Lone Woman of San Nicolas Island] put several pieces of the asphaltum, which is found in great quantity along the beach, in the bottom of the basket, and then on the top of them some hot pebbles. When the asphaltum was melted, by a quick, rotary motion, she would cover the inside of the basket with an even coating, after which the surplus, with the rocks, was thrown out. These baskets were water-tight, and would last a long time [Nidever 1973:34].*

Woven asphaltum-lined basketry water bottles have been found in a variety of archaeological contexts in island and coastal mainland sites across southern California (Grant 1978; Hudson and Blackburn 1983:39–54; Mohr and Sample 1955). The antiquity of basketry water bottles in the region is known not from the basketry itself, which rapidly disintegrates, but from impressions left behind on the asphaltum lining (Bleitz 1991; Braje et al. 2005; Erlandson 1997; Reinman and Townsend 1960; Rick 2007; Wilcoxon 1993). These impressions have been the focus of numerous studies and have provided the basis for understanding the evolution of basketry technology on the Channel Islands (Bleitz 1991; Braje et al. 2005; Rozaire 1976; Rozaire and Craig 1968). Additional indirect evidence for water bottle production comes in the form of small stones covered with asphaltum that are referred to as tarring pebbles, which were used to coat the interior of basketry water bottles and for spreading asphaltum on other tools (Craig 1966; Hudson and Blackburn 1987:174–175).

Tarring pebbles have a long history of use in California dating to at least the Early Holocene. Walker (1952) noted the presence of tarring pebbles in Stratum 1 at Malaga Cove, which is older than 6500 BP (Moratto 1984; Sutton and Grenda 2012). On Santa Cruz Island, a tarring pebble was found in a small shell midden dated between about 6800 and 4800 cal BP (Perry 2004:121). On San Miguel Island, two tarring pebble features were identified eroding out of a deeply buried shell midden dated to 5130 cal BP (Braje et al. 2005). Tarring pebbles appear to have increased in frequency during the Middle Holocene, when asphaltum use became more intensive and diverse (Erlandson et al. 2008; Glassow et al. 2007). By the Late Holocene, tarring pebbles became significantly more prevalent, as demonstrated at various archaeological sites such as Pitas Point in the Santa Barbara Channel region where 651 tarring pebbles were excavated within concentrated activity areas (Gamble 1983). Recent analysis at CA-SNI-25 on San Nicolas Island revealed a total of 664 tarring pebbles within a 16 × 15 m horizontal exposure.

Early explorers and archaeologists have described finding small ($n = 13$) and large ($n = 160$) heaps of tarring pebbles across archaeological sites in southern California (Rogers 1930; Rozaire 1967; Schwartz 1991; Woodward 1939, 1940, 1957). Schumacher (as cited in Jones 1969:94) likened the tarring pebble to "a pigeon's egg," while Nidever (1973:14) compared it to "a walnut," and Woodward (1957:248) described it as being as large as "a tennis ball." Although few reports and no detailed analyses have ever been completed, it is clear from historical accounts that tarring pebbles were diverse and abundant in both mainland and Channel Island sites. Over the past 30 years, attempts have been made to analyze tarring pebbles more thoroughly. For the Santa Barbara mainland coast, Gamble's (1983) study at Pitas Point distinguished between small (<5 cm) and large (>5 cm) tarring pebbles. In Salwen's (2011) typological model exploring asphaltum utilization, tarring pebbles were classified in the "smeared" category based upon their function as asphaltum applicators. However, for most archaeological investigations in southern California, tarring pebbles have not been systematically documented or quantified and no other detailed descriptions or typologies have been developed.

Given that tarring pebbles are some of the best preserved artifacts in the archaeological record, examination of such specimens can offer significant insights into the organization of asphaltum-related activities and the production of asphaltum artifacts. In this article, we investigate tarring pebble clusters found at three archaeological sites on San Nicolas Island and establish a typology and classification scheme based on pebble size (Table 1). We provide a standardized system to analyze tarring pebbles, cooking stones, and other unmodified rounded pebbles for studies in California and around the globe. Using this classification scheme, we demonstrate that tarring pebble size is uniform within clusters and varies between sites and through time. We discuss the possibility that tarring pebbles served a variety of asphaltum-related activities in antiquity, the archaeological evidence for which has yet to be interpreted. These activities provide an explanation for the evident size variation among tarring pebbles in the archaeological record on San Nicolas Island.

Background

San Nicolas Island is the outermost of the eight Channel Islands off the California coast (Figure 1). The island is situated approximately 122 km (75.8 mi) southwest of Los Angeles and 110 km (68.4 mi) from the nearest point on the mainland. Its closest neighbors are Santa Barbara Island, located 46 km (28.6 mi) to the northeast, and Santa Cruz Island, which is 77 km (47.8 mi)

Table 1. Tarring Pebble Constituents within Deposits.

Site	Unit	Volume (m^3)	Total Count	Average Weight	Average Length	Average Width	Average Height	Std Dev	Small	Medium	Large	Extra Large
CA-SNI-25	East Locus	36.16	664	6.40	21.21	16.28	12.27	4.72	58	578	28	–
CA-SNI-25	7V	0.12	30	6.33	22.26	17.47	14.02	2.67	–	30	–	–
CA-SNI-40	12A	0.16	71	21.64	32.42	23.71	18.14	6.74	–	15	56	–
CA-SNI-161	Surface	–	80	38.88	37.99	32.84	24.85	3.71	–	–	78	2

Note: Metric measurements in g and mm.

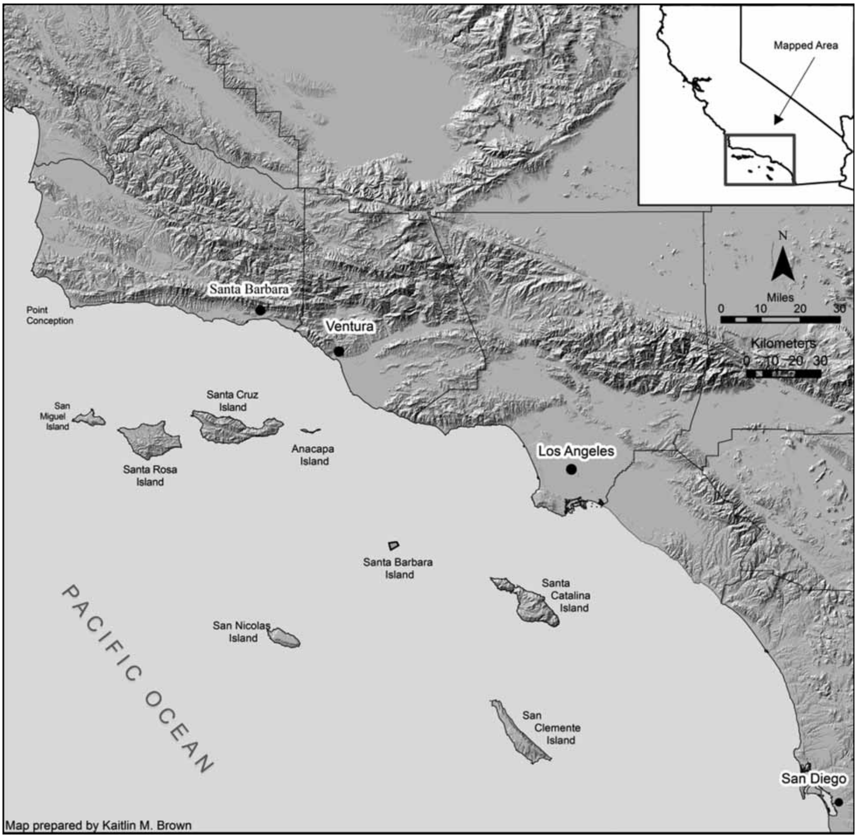

Figure 1. Map of the Southern California Bight showing the location of San Nicolas Island.

to the north. San Nicolas Island is relatively small, measuring approximately 15 km (9.3 mi) long and 6 km (3.7 mi) wide, extending over an area of 58 km^2 (22.4 mi^2).

The island is composed of Eocene sedimentary rock, including sandstones, siltstones, shales, and conglomerates (Schoenherr et al. 1999; Vedder and Norris 1963). At least nine quarried outcrops of pebbles and cobbles have been located throughout the island (Clevenger 1982). The island's botanical resources consist of various forms of coastal scrub, grassland, and wetland communities (Junak 2008). Native land animals include the land snail, island night lizard (*Xantusia riversiana*), and the San Nicolas Island deer mouse (*Peromyscus maniculatus exterus*) (Martz 2008; Schoenherr et al. 1999). The Island fox (*Urocyon littoralis*) was likely introduced by Native Americans during the

Middle Holocene (Vellanoweth 1998). Although terrestrial resources are poorly understood, a rich marine environment surrounds the island and plays host to a variety of plants, shellfish, fish, and pinnipeds (Meighan 1954; Meighan and Eberhart 1953; Schoenherr et al. 1999).

Ethnographically, very little is known about the people who once inhabited San Nicolas Island. Archaeological evidence implies that the island has been inhabited since at least 8000 BP (Vellanoweth and Altschul 2002) and population density reached its peak during the Late Holocene (Martz 2008). By European contact, the southern Channel Islands were occupied by Takic speakers of the Uto-Aztecan language family (Golla 2007, 2011; Kroeber 1925). After the removal of the islanders to mainland Spanish missions in the early nineteenth century, the "Lone Woman of San Nicolas Island" lived by herself on the island for 18 years (Heizer and Elsasser 1973). Today we call the native people of San Nicolas Island the Nicoleño. Linguists consider them to be closely related to the Gabrielino and other Takic groups (Bean and Smith 1978; Kroeber 1925).

Materials and Methods

The data set for this analysis consists of tarring pebbles collected from archaeological investigations at three separate sites on San Nicolas Island. A total of 2,334 pebbles and pebble fragments were analyzed for asphaltum residue. Overall, the pebble assemblage is relatively well preserved, with 845 (36 percent) of the pebbles clearly showing asphaltum residue. More than 1,000 of the pebbles without asphaltum exhibit signs of heating, including spalls and cracks. Slightly less than 300 pebbles show no modification at all.

Preliminary analysis began with culling tarring pebbles and other unmodified pebbles from previous field excavations on San Nicolas Island. All pebbles were pulled from artifact boxes and examined in a laboratory for asphaltum staining or residue. Staining is a consistent characteristic that leaves the cortex of the pebble with a thin coat of black residue. Pebbles with asphaltum or staining were separated from pebbles without asphaltum or staining. The former were catalogued and labeled as tarring pebbles while the others were catalogued merely as pebbles or heat-treated pebbles.

All pebbles were examined using an illuminated 10× magnifying glass. Surface inspection included a systematic description of all pebble facets, cracks, and other porous sections. Tarring pebbles were measured using digital calipers to the hundredth millimeter, weighed on a digital balance to one hundredth of a gram, and entered into a database. Tarring pebbles

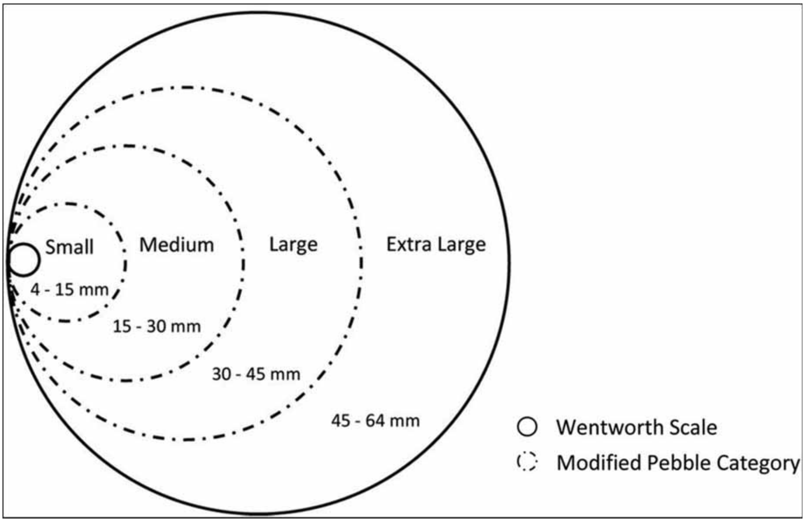

Figure 2. Modified pebble categories in the Wentworth (1922) classification scheme.

were described as "coated" if over 50 percent of the cortex was covered with asphaltum, "partially coated" if 10 to 50 percent was covered, and "trace residue present" if less than 10 percent was visible on the pebble surface. We used a two-tailed t-test to measure the statistical differences between categories.

After preliminary descriptive and statistical analysis of the pebble assemblages, we developed a typology and classification scheme congruent with modern sedimentological standards for particle size analysis, and we integrated our pebble typology into the Wentworth scale developed in 1922. The Wentworth scale defines specific grade sizes for rounded clastic fragments that include boulders (>256 mm), cobbles (256 to 64 mm), pebbles (64 to 4 mm), and granules (4 to 2 mm), as well as sands, silts, and clays (Wentworth 1922). We modified the Wentworth classification for pebbles based on maximum diameter, and divided them into four categories: small (4 to 15 mm), medium (15 to 30 mm), large (30 to 45 mm), and extra large (45 to 64 mm) (Figure 2). We further divided the categories into 5 mm increments and found that the tarring pebbles clustered into 15 mm intervals. A scatter plot was constructed using the maximum length and width of the individual tarring pebbles within the clusters (Figure 3). In the following section, we discuss the application of our classification scheme on the tarring pebbles from San Nicolas Island.

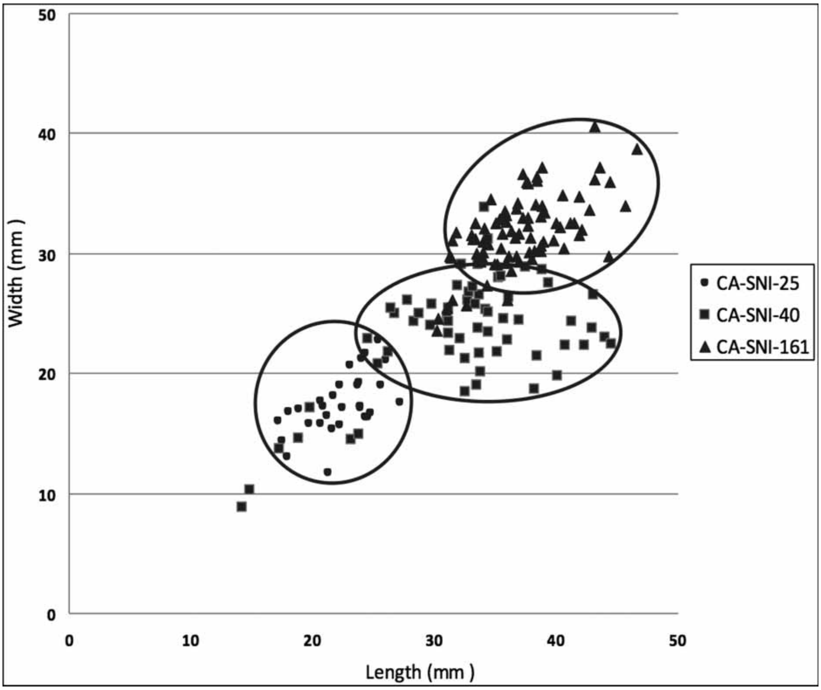

Figure 3. Scatter plot showing size clustering among tarring pebbles at the three study sites on San Nicolas Island.

Results

After implementing the methods described above, we found clear distinctions in tarring pebble sizes between sites. The sites from which the pebbles were collected, all situated on the northwest end of the island, vary in type and chronology. Below is a brief discussion of site context, as well as pebble attributes and size categories for the three tarring pebble assemblages. Overall, the tarring pebbles analyzed were well preserved and easily identifiable (Figure 4). Two of the tarring pebble assemblages (CA-SNI-40 and CA-SNI-161) were found tightly clustered within midden deposits and were excavated as features. The assemblage from CA-SNI-25, sampled (0.12 m^3) from a large excavation area (36.16 m^3), was recovered from a single 1 × 1 m unit.

CA-SNI-25

Known as the Tule Creek site, CA-SNI-25 consists of the remains of a large Late Holocene village underlain by earlier deposits, and located on top of a series of

Figure 4. Examples of medium (CA-SNI-25), large (CA-SNI-40), and extra large (CA-SNI-161) tarring pebbles from the three study sites on San Nicolas Island.

uplifted marine terraces on the north coast of San Nicolas Island. The site is situated 3.2 km (2 mi) southeast of Thousand Springs and directly above Corral Harbor, a small protected cove suitable for launching and landing watercraft. Occupied since 4000 cal BP, the site's main occupation occurred from 540 cal BP to European contact (Martz 2008). First described by Rogers (1930), the site contains numerous pit house depressions, communal structures, and at least two cemeteries. The villagers extensively utilized marine resources for food and material needs; however, non-native materials such as Coso obsidian, Santa Catalina Island soapstone, and chert from the northern Channel Islands provide information about past trade networks in the region (Cannon 2006). Recent investigations have revealed the remains of pits, middens, and ceremonial features, including formal dog and fox burials (Bartelle et al. 2010; Vellanoweth et al. 2008).

We analyzed 2,198 pebbles from the site's East Locus and found that only 664 (30 percent) pebbles had asphaltum residue visible on their surfaces. Tarring pebbles include metavolcanic and metasedimentary varieties with a size range between 6.64 and 38.25 mm and an average weight of 6.4 g. Averages for length (21.21 mm), width (16.28 mm), and height (12.27 mm) suggest that medium tarring pebbles predominate in the assemblage. In fact, 578 (87 percent) tarring pebbles from CA-SNI-25 measured between 15.08 and 29.60 mm, clearly falling within the medium category. The other tarring pebbles were distributed between 58 (9 percent) in the small category and 28 (4 percent) in the large category.

Few tight clusters of tarring pebbles were found at CA-SNI-25. While pebbles were ubiquitous in most deposits at the site, their occurrence was diffuse rather than clustered. A feature composed of a cluster of 30 tarring pebbles recovered within the same stratum of a 1 × 1 m unit was an exception, so we compared it to clusters from the two other sites described in this article. The cluster from CA-SNI-25 was found in Unit 7V adjacent to a large hearth and numerous pit features. Based on the overall dimensions, the tarring pebbles from Unit 7V conform to the site trends: length = 22.62 mm, width = 17.47 mm, height = 14.02 mm, average weight = 6.33 g (Table 1). Overall, the pebbles in the cluster weigh a total of 224.36 g and range in length between 17.02 and 27.21 mm, well within the medium category.

CA-SNI-40

CA-SNI-40 is a large dune and midden site on the northwest tip of San Nicolas Island. The dune is about half a mile (800 m) long running northwest to southeast and is approximately 200 ft (70 m) wide. The site was tested by the UCLA Archaeological Survey in 1959 when a cemetery and an adjacent shell midden were documented (Reinman and Townsend 1960). The burial area is located on the inland slope of the dune and the shell midden skirts its edge. In 2010 and 2011, archaeological investigations conducted by the authors during a field school sponsored by California State University, Los Angeles (CSULA), focused on the midden deposits. Based on radiocarbon dating of shells recovered during these excavations, the site appears to have been occupied during the Middle Holocene between about 4300 and 3700 cal BP (Table 2).

In the summer of 2011, we partially excavated a tarring pebble feature at CA-SNI-40 and collected 71 pebbles in association with a shell and ash feature, chunks of asphaltum, ochre, *Callianax* (formerly *Olivella*) *biplicata* beads, and numerous expedient flake tools and manufacturing debris. Each tarring pebble was mapped and packaged for transport in acid-free tissue for laboratory analysis. The tarring pebbles were photographed from different angles and point provenience was recorded for every pebble. Overall, the pebbles consist of well-rounded, dark reddish gray (2.5YR 4/1), metavolcanic rocks with a total weight of 1,515 g. The average length (32.42 mm), width (23.71 mm), and height (18.14 mm) are consistent with large size pebbles,

Table 2. CA-SNI-40 Locus E Radiocarbon Dates.

Lab Code	Locus	Unit	Stratum/ Level	Material	Radiocarbon Age	+/–	cal BP (1σ)	cal BP (2σ)
OS-85194	E	9	IA/1	*H. cracherodii*	4150	30	3836–3969	3774–4063
OS-105783	E	11	IIHC/1 (Dark Soil)	*Mytilus californianus*	4400	30	4340–4181	4401–4117
OS-85193	E	12	IA/1	*H. cracherodii*	4070	35	3719–3867	3660–3950
OS-85198	E	12	II/1	*Diomede* sp.	4480	30	4286–4423	4224–4501
OS-105786	E	12	IIHC/ transition	*H. cracherodii*	4370	40	4302–4128	4389–4064
OS-96262	E	12A	IIHC/SU/1	*H. cracherodii*	4170	25	3857–3991	3818–4072
OS-105789	E	12A	IIHR	*H. cracherodii*	4180	25	4010–3870	4078–3826
OS-105784	E	10A/ 12A	Ash Feature	*Tegula* spp.	4300	30	4206–4049	4263–3962
OS-105785	E	10A/ 12A	Ash Feature	*Mytilus californianus*	4220	30	4072–3930	4139–3861
OS-96263	E	10A/ 12A	Shell Ash Feature	*H. cracherodii*	4230	35	3934–4085	3858–4159

All dates calibrated with Calib 7.0 (Stuiver and Reimer 1993) and adjusted to Hughen et al. (2004) using a ΔR of 225 ± 35 years.

according to our definition (Table 1). The tarring pebbles range in length between 14.24 and 44.5 mm with 15 (21 percent) pebbles in the medium category and 56 (79 percent) in the large category.

CA-SNI-161

CA-SNI-161 is located on the northwest shore of San Nicolas Island near Vizcaino Point. The multicomponent dune site sits on an uplifted marine terrace overlooking the intertidal zone. The site covers approximately five acres (20,000 m^2) and has shell, lithic, and bone debris on the surface. It is part of a continuous chain of coastal sites that ring the northern and western edges of the island. Investigations of the site were conducted between 1991 and 1993 by archaeologists from CSULA in order to mitigate the effects of constructing a bird blind. CA-SNI-161 has relatively good stratigraphic integrity with

Table 3. Statistical Significance for Tarring Pebbles between Archaeological Assemblages.

Sites compared in t-test		Level of significance	C.I.	*t*	*p*	*df*	*SE*
CA-SNI-25	CA-SNI-40	Extremely statistically significant	95%	7.983	0.0001	98	1.274
CA-SNI-25	CA-SNI-161	Extremely statistically significant	95%	20.061	0.0001	108	0.74
CA-SNI-40	CA-SNI-161	Extremely statistically significant	95%	5.365	0.0001	148	0.873

Note: C.I., confidence interval; df, degrees of freedom; SE, standard error.

well-preserved cultural deposits that suggest four occupational phases (Porcasi 1995; Vellanoweth 1996).

A discrete cluster of 80 tarring pebbles was discovered on top of the site and was salvaged before wind and water erosion obliterated its context. Excavations at the site suggest that the pebbles were associated with deposits that were radiocarbon dated between 5400 and 2900 cal BP (Vellanoweth 1996). The cluster feature was photographed and documented *in situ* prior to wrapping each pebble in scratch-free tissue; these were numbered, labeled, and packaged for transportation off the island. The pebbles were carefully inspected and found to vary in asphaltum coverage: 17 percent were completely coated, 62 percent were partially coated, and 21 percent had trace residue and staining. In total, the pebbles consisted of metavolcanic (68 percent) and metasedimentary (42 percent) rocks, weighing 3119.98 g and measuring an average of 37.99 mm long, 32.84 mm wide, and 24.85 mm thick (Table 1). A total of 78 (97.5 percent) tarring pebbles measured within the large category and two (2.5 percent) fell within the extra large range.

A two-tailed *t*-test demonstrated differences between clusters of tarring pebbles at the archaeological sites investigated in this study (Table 3). Results for all tests indicate that the differences between clusters were extremely statistically significant. We found that pebble size was highly uniform within clusters, yet varied markedly between clusters.

Discussion

The classification scheme presented here provides a method to examine variation in tarring pebble size within and between archaeological sites. Among the 80 tarring pebbles collected from CA-SNI-161, for instance, 78 (98 percent) were of the large category, clearly demonstrating that whoever collected these pebbles sought out a particular size. The size of tarring pebbles at CA-SNI-40 also showed a distinct pattern; 79 percent ($n = 56$) were large, and 21 percent ($n = 15$) were medium, according to our scheme. Although tarring pebble distribution at CA-SNI-25 was more diffuse throughout the site, 87 percent ($n = 578$) of the pebbles fell into the medium size category. We argue that the cluster features found at CA-SNI-40 and CA-SNI-161 represent distinct tarring activities, whereas the pebbles from CA-SNI-25 signify a range of activities consistent with village life.

If the features at CA-SNI-40 and CA-SNI-161 represent distinct activities, then what guided the decision to select certain pebble sizes? The ethnographic record portrays a variety of activities that may be linked to tarring pebble size, especially the construction of basketry water bottles (Craig 1966, 1967; Gamble 1983; Hudson and Blackburn 1983). Did water bottle size and form dictate pebble size, or did the material out of which the bottle was constructed determine tarring pebble size? Could pebble size represent a variety of tarring activities beyond basketry construction? Does tarring pebble size reflect the nature and character of the quarry being exploited? The following discussion addresses these and other questions to offer explanations for tarring pebble size and use on San Nicolas Island.

Water Bottle Types and Materials

Woven basketry water bottles were fashioned in a variety of shapes and sizes and were made for both individual and household consumption (Hudson and Blackburn 1983). Long-necked water bottles were about 25 cm tall with a diameter of about 15 cm (Heizer 1960). Small water bottles stood about 45 cm tall and tapered towards a narrow neck (Craig 1967). Large water bottles were tubular in shape, had a short neck, and could store large quantities of water (Hudson and Blackburn 1983:39). These water bottles would likely have been coated using different sized pebbles depending upon the bottle's overall size and mouth diameter.

Many plant species were used in the construction of water bottles, including three-leaf sumac (*Rhus trilobata*), rushes (e.g., *Juncus textilis*), and many types of reeds and grasses (Poaceae) (Craig 1967; Dawson and Deetz 1965; Timbrook 2007). Evidence for the use of woven sea grass (*Phyllospadix* sp.) has been found throughout the Channel Islands (Braje et al. 2005; Connolly et al. 1995; Heizer 1960; Heye 1921; Rogers 1929; Rozaire 1959) and has been the most referenced water bottle construction material among the islanders. It is presumed, at least on San Nicolas Island, that people exhausted terrestrial plant resources and turned to the ocean for basketry material (Rozaire 1967).

However, some families of plants ethnographically known to have been employed by Native Americans for basketry material have representative species on San Nicolas Island, including Juncaceae (toad rush [*Juncus bufonius*]), Cyperaceae (three-square [*Schoenoplectus americanus*]), and a variety of grasses (Junak 2008).

The medium tarring pebbles examined at CA-SNI-25 may reflect construction of long-necked water bottles fashioned out of sea grass as exemplified in the ethnographic accounts of Juana Maria (Heizer and Elsasser 1973). These baskets are described as often being lopsided in shape and flexible (Heizer 1960; Woodward 1940, 1957). Smaller pebbles were needed for such baskets, as only these could pass through the narrow neck and weigh less, allowing more mobility in coating the interior.

Larger tarring pebbles may indicate different basket size and material. For instance, the large tarring pebbles from CA-SNI-40 were able to fit through a wider opening and were perhaps used in conjunction with stiff construction material. This evidence fits nicely with Woodward's (1939, 1957) descriptions of larger tarring pebbles being more recognizable at mainland sites where stiffer materials were used, and smaller pebbles being more noticeable in island deposits.

Pebble Quarry Variation

Like other lithic artifacts, tarring pebbles are part of a technological and cognitive system. The cluster features examined for this study may represent single pebble quarrying and tarring events and thus allow us to interpret the selection strategies of individual actors in antiquity. Behaviors such as collecting pebbles of a specific size and color could reflect an individual's preference within a set of culturally defined production parameters. At CA-SNI-40, for example, the tarring pebbles in the analyzed cluster are composed of the same dark reddish gray (2.5YR 4/1) stone. Such specific attributes may represent selection on the basis of subjective and symbolic qualities.

Specific quarries may have been selectively mined if the pebbles they contained possessed desirable attributes such as size, material, density, and color. Two of the nine quarries identified on San Nicolas Island by Clevenger (1982) are located in close proximity to CA-SNI-40 and CA-SNI-25. Pebble sources on the island tend to be poorly sorted, containing a variety of pebble sizes. However, quarry exploitation through time would affect the size categories present today if people targeted specific pebbles with certain characteristics. After the excavation of CA-SNI-40, we surveyed one quarry adjacent to the site and found few pebbles that matched the size of the tarring pebbles excavated from the site. It is possible that the pebbles were acquired at a different quarry, although other characteristics (such as material type) are consistent with the material at the local source.

Other Uses for Asphaltum

The convention in California archaeology has been to consider tarring pebbles solely as evidence of water bottle manufacture. However, ethnographic accounts describe the use of heated stones to melt asphaltum for other purposes. Heizer (1943) described a technique that he likened to soldering: "Ingenious methods for applying the bitumen had been developed by these Indians—a long slender stone was heated and placed in contact with the asphaltum lump; this caused the substance to flow freely on the object where it was required." At European contact, several native cultures in southern California used asphaltum for a range of purposes, including as an adhesive for mending broken objects and hafting tools, to fasten beads to clothing and other items, and to caulk plank canoes (Arnold 1993; Fauvelle et al. 2012; Gamble 2008; Gutman 1979; Hodgson 2004; Hudson and Blackburn 1983, 1987; Hudson et al. 1978). Evidence of asphaltum preparation has been found in archaeological contexts in the form of interior-stained steatite ollas and shells and coated baskets. Asphaltum applicators were fashioned from a variety of easily accessible local materials such as bone, shell, and stone.

At CA-SNI-25, the frequency of interior-stained abalone dishes unaffected by fire suggests that the asphaltum they once contained was melted by means other than placing the shell directly on a hearth. One possible explanation is that pebbles were used as heating stones to melt solid asphaltum in abalone mixing dishes. This technique would represent a logical extension of the pan-Californian practice of cooking foods such as atole in baskets by adding fire-heated cooking stones to boil the mush (Hudson and Blackburn 1983:175–184; Jennings 1974; Kroeber 1925). Archaeologically, pebbles used to apply asphaltum would be very difficult to distinguish from pebbles used solely to melt asphaltum.

Medium-sized tarring pebbles appear in different contexts from East Locus at CA-SNI-25 and are associated with various asphaltum occurrences. These tarred pebbles may reflect a range of activities including melting asphaltum in mixing dishes and applying asphaltum to various items. Likewise, large tarring pebbles could indicate a larger scale activity. For example, the tarring pebbles from CA-SNI-161 weigh more than six times the average pebble at

CA-SNI-25 and almost twice the average at CA-SNI-40. Additionally, the discrete cluster in which the pebbles at CA-SNI-161 were found suggests that they were used for a single purpose. The pebbles, averaging nearly 40 mm in diameter, could have been used to coat the interior of a basketry water bottle; however, because of the number of pebbles found in the feature, the cluster may indicate that multiple bottles were coated during a single event. Alternatively, they could also have been used as melting stones for other tarring activities. With their greater capacity to hold heat, these large pebbles may have been used to melt asphaltum in greater quantities than a mixing dish. The tarring pebble cluster at CA-SNI-161 may be evidence of melting asphaltum in large vessels using the hypothesized heating stones method mentioned above for activities requiring large quantities of asphaltum, potentially the caulking of watercraft.

Environmental and Cultural Change

Although we have provided a variety of explanations for why tarring pebble size might vary, many factors make it difficult to pinpoint a single cause. Pebble size variation through time might be related to external forcing agents such as environmental change. The two sites with large pebbles, CA-SNI-40 and CA-SNI-161, were occupied during the Middle Holocene at a time of warmer and drier climate. Based on changes in sea surface temperature, the Middle Holocene and Late Holocene had two warm-water intervals between 5900 and 3800 BP and 2900 and 1500 BP (Kennett 2005: 65). According to Gamble (2005), the Chumash stored water in an effort to cope with environmental factors responsible for causing episodes of drought. Braje et al. (2005) presented evidence of asphaltum basketry impressions from San Miguel Island that dated to 5100 cal BP, suggesting the development of asphaltum-sealed water bottles in response to arid conditions.

Additionally, water bottle types may be attributed to cultural differences. Based on burial practices, skeletal variations, and artifact styles, archaeologists have shown that by at least 3,000 years ago a population replacement may have occurred on San Nicolas Island (Martz and Rosenthal 2001). Technological knowledge, passed down through generations, can reveal stylistic elements that reflect ethnicity (Rosenthal 1994). Large tarring pebbles from CA-SNI-40 may represent the technological characteristics of mainland populations who immigrated to the islands. Medium tarring pebbles, found throughout East Locus at CA-SNI-25, show distinctive traits *vis-à-vis* tarring pebble selection and asphaltum usage that may reflect a unique Nicoleño identity developed in isolation on the island.

Conclusion

It is our hope that this article will guide future studies on tarring pebbles and other unmodified, rounded stones. Building a typology has allowed us to demonstrate that sizes of tarring pebbles within clusters are not a random occurrence. Rather, the pebbles were chosen based on a certain set of criteria: they needed to be of a uniform size and weight to complete the task at hand. Our typology has also allowed us to distinguish between clusters. The different sizes of tarring pebbles from CA-SNI-25 and CA-SNI-161 are just one example of the extent of variation between tarring pebble clusters. We suggest that size disparity indicates different tarring activities that may no longer be visible in the archaeological record. By creating a standardized system to analyze pebble categories, our typology can fill in technological gaps for understanding the variety of uses to which tarring pebbles were applied, and the range of asphaltum activities within sites. Future work will continue to add to our knowledge of prehistoric asphaltum use throughout the Southern California Bight.

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