THE ARCTIC SMALL TOOL TRADITION ON COOK INLET: THE MAGNETIC ISLAND SITE, TUXEDNI BAY, ALASKA

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ABSTRACT

The Magnetic Island site (Tuxedni Bay, Lower Cook Inlet), excavated in 2012, provides the first evidence for an Arctic Small Tool tradition (ASTt) occupation on the west shore of Cook Inlet. Dating analyses indicate a relatively brief occupation period of ca. 3400–3800 cal BP. Tephra deposits capping the cultural levels suggest that environmental impacts resulting from volcanism played a role in the cessation of the Magnetic Island occupation. Data from this project expand our knowledge of ASTt dispersal in southcentral Alaska and provide a potential link between previously known sites on the Alaska Peninsula and in Kachemak Bay.

INTRODUCTION

KEN-00324, the Magnetic Island site, is located in Tuxedni Bay on the west shore of lower Cook Inlet, Alaska (Fig. 1), within the boundaries of Lake Clark National Park and Preserve. The site was initially tested during a National Park Service survey in 1996, revealing two superimposed hearths within a cultural zone radiocarbon dated to about 3500 ^{14}C years BP. The two hearths present in the 1996 test unit were marked by charcoal, lithic debris, and hearth stones (Crowell 1996). In September 2012, a team of archaeologists undertook more extensive excavations at the site in order to document its physical condition and to collect sufficient data to evaluate the site's significance and nomination to the National Register of Historic Places (Rogers et al. 2012).

The age of the cultural component at KEN-00324 makes data contained in the deposits very valuable for reconstructing the cultural chronology in Cook Inlet, especially for the western shore of the inlet and the region north of Kachemak Bay. A gap exists in the culture history for Cook Inlet between ca. 4000 and 3000 BP, particularly in the upper Cook Inlet area (Reger 1998; Workman 1998). The presence of an Ocean Bay II occupation sometime in that period comes from undated, scattered artifacts, as well as an Arctic Small Tool tradition (ASTt) occupation in Kachemak Bay dated to ca. 4000 BP, but there are no previous well-documented collections dating between approximately 4000 and 3000 BP. Filling that gap in the cultural framework is a major contribution from KEN-00324.

LOCATION AND ENVIRONMENTAL CONTEXT

Magnetic Island is located on the rugged north shore of Tuxedni Bay, approximately 14.5 km west of the north entrance to the bay (Fig. 2). The archaeological site, KEN-00324, consists of a group of distinct surface depressions situated on a rocky platform on the southeast corner of the island, approximately 14 m above current sea level. The high rocky feature on which the site is located connects to the larger, 152-meter-high Magnetic Island prominence via a low ridge. The ridge has the appearance of a tombolo feature from a time when relative sea levels were higher. The surrounding vegetated tidal flats become submerged during the highest tides, and margins of the flat platform are vertical rock cliffs with access to the tidal flats at only a single steep approach.

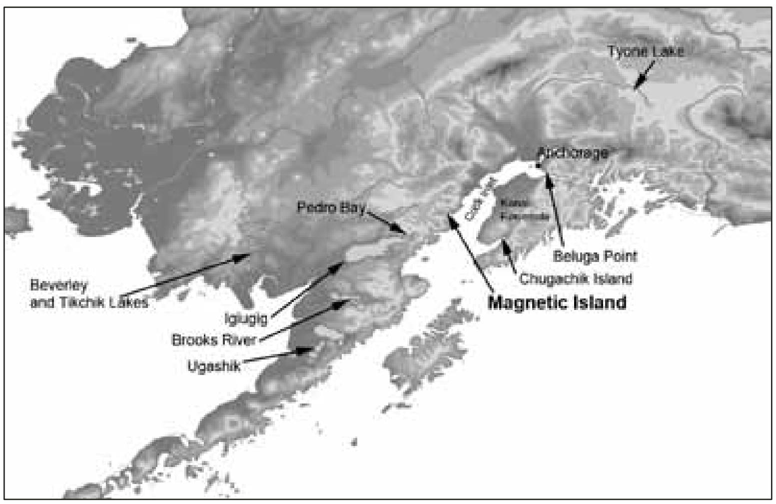

Figure 1. KEN-00324 site location on lower Cook Inlet, Alaska.

Figure 2. View of Magnetic Island from Tuxedni Bay.

The island bedrock was mapped by the U.S. Geological Survey in 1951 during an investigation of reported deposits of magnetite on the island, hence the name (Grantz 1956). The dominant bedrock in the vicinity of KEN-00324 was identified as intrusive quartz diorite with adjacent, more extensive outcrops of quartz monzonite. Redoubt Volcano is located approximately 28 km north of KEN-00324 and Iliamna Volcano lies 25 km to the south (Fig. 3). Both have contributed to the complex surficial geology of the area.

The glacial history of the Tuxedni Bay area is poorly understood due to a general lack of glacial deposits. Detterman and Hartsock (1966) mapped late Pleistocene and Holocene glacial moraines near the present terminus of Tuxedni Glacier, some 9.5 km northwest of the site. A small remnant moraine attributed to the Naptowne Glaciation is located on the north shore of the bay, and some Naptowne-age deposits are mapped in drainages entering Tuxedni Bay from the south. None of the latter mapped units reached the bay, as they are obscured by more recent alluvial and colluvial deposits. The end of the most recent stage of the Naptowne Glaciation is dated in other parts of the Cook Inlet basin to about 11,000 years ago (Reger et al. 2007). Moraines of the Alaskan Glaciation of Holocene age are located close to the present terminus of the Tuxedni Glacier (Detterman and Hartsock 1966). The Alaskan Glaciation has been dated on the Kenai Peninsula from about 5000 to 2500 years BP (Karlstrom 1964). Presence of glacial ice may have restricted human passage through the upper Tuxedni Bay valley during the occupation of KEN-00324, but the ice would have remained at least 9.5 km from the site location. Access to the Iliamna Lake area via the Pile River drainage may have been possible during Alaskan Glaciation advances, although travelers would have probably encountered some glacier traverses.

Evidence of volcanic activity in the vicinity of Redoubt Volcano during the middle to late Holocene has been well documented (Schiff et al. 2010). The Holocene eruptive history of Iliamna Volcano has been much less studied and seems to have been less active than Redoubt Volcano. Lava from Iliamna Volcano flowed primarily south and east during the

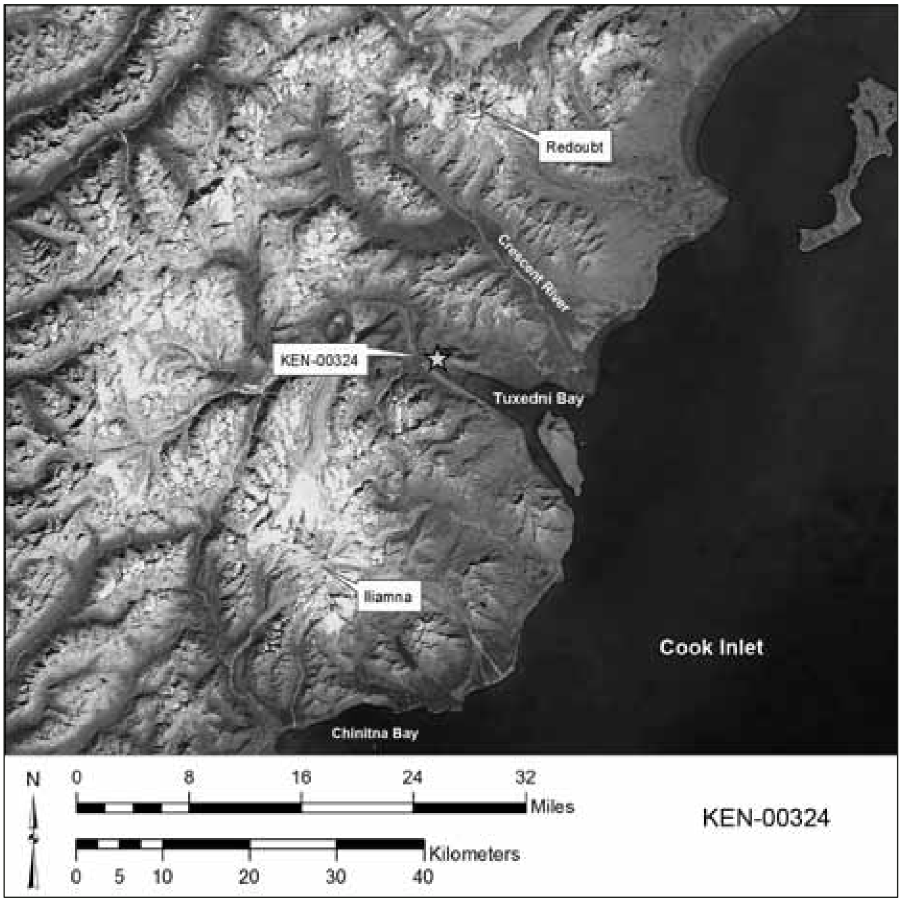

Figure 3. Site location in relation to Redoubt and Iliamna volcanos.

height of the Naptowne Glaciation, the last major glacial episode (Juhle 1955). Naptowne-age till in the Red River and Johnson River drainages contains high percentages of Iliamna-derived lava (Detterman and Hartsock 1966).

Redoubt Volcano, located 28 km north of KEN-00324, displays a very active history through the Holocene era. Although shielded from the site area by an intervening high mountain ridge, tephra from the volcano doubtless contributed significantly to sediment accumulation at KEN-00324. The Crescent River drainage, north of the mountain ridge, has been extensively affected, with lahars (volcanically induced debris flows) flowing to the Cook Inlet shore several times approximately 3,500 years ago (Riehle et al. 1981). The age of the older of two lahars has been dated to about 3,600 years ago (Begét and Nye 1994). A series of later lahars (ca. 3,600 to 1,800 years ago) altered the upper Crescent River valley landscape as well. Begét and Nye (1994) conclude that tephra from Redoubt Volcano rained down south of the mountain for another 1,800 to 2,000 years after deposition of the 3,600-year-old lahars. The Crescent River lahars demonstrate the high frequency of volcanic activity through the period of site occupation.

The presence of vegetated tidal flats surrounding Magnetic Island raises questions about the origin of the intertidal sediments and their relationship to possible sea level changes. The location of KEN-00324 suggests that the occupants of the site may have seen very different terrain than is present now. Detterman and Hartsock (1966) cite various lines of evidence for higher relative sea level in the recent past, but the age of changes remains unclear. They note a wave-cut notch 7.5 m above the present beach on Gull Island in the mouth of Chinitna Bay as a possible result of uplift. Other lines of evidence are the presence of raised beaches considerable distance from present beaches on the Iniskin Peninsula and at the mouth of the Johnson River. The oldest (highest) beach ridges at Johnson River are 6 to 9 m above present sea level. Raised, vegetated beach ridges are situated parallel to and inland from the present beach south of the Johnson River. North of Redoubt Volcano, between Harriet Point and Drift River, Riehle and Emmel (1980) mapped raised shorelines just behind the present Cook Inlet beach. Tectonic or isostatic uplift are probable reasons for those features (cf. Combellick 1991). The cumulative evidence, while fragmentary, suggests a general uplift of land relative to sea level. The amount of uplift may be as much as 7.5 m, which would place KEN-00324 about 5 to 7 m above the adjusted sea level. Age of the relative sea-level high stand is unclear, as noted above, but the radiocarbon dates from KEN-00324 may be the best age estimate available.

Past vegetation, identified in fossil pollen profiles, has been documented only on a regional level. The nearest location where pollen samples have been collected is at Bear Lake near the base of Redoubt Volcano. The samples, collected by James Riehle and Thomas Ager during the early 1980s, remain only partially studied and are not yet published (Ager and Sims 1984).

Radiocarbon dating of the profile is problematic due to a lack of dated samples. Later columns extracted to study volcanic tephra were collected in different areas of the lake and do not extend to late Pleistocene sediments (T. Ager, pers. comm. 2012).

The nearest published pollen study locations are near Homer on the Kenai Peninsula, located 175 km southwest of Magnetic Island (Ager 2000). Regrowth of vegetation for that area began about 12,800 years ago, after the retreat of Pleistocene ice, with herbaceous tundra. Shrub tundra, featuring dwarf birch and willows, replaced the herbaceous tundra soon after initial vegetation growth. Alders (*Alnus*), willows (*Salix*) and deciduous trees (*Populus*) were dominant by 9,500 years ago, a vegetation community that lasted until the later Holocene. Ager (2000) dates the entry of spruce into the Homer area by 3,800–4,000 years ago. A coastal forest mix with Sitka spruce established in the area by 1,650 years ago, and that scenario might be extrapolated to the west shore of Cook Inlet near Tuxedni Bay. Ager has noted, however, that spruce of any variety did not enter the Bear Lake pollen profile until very late, within the past 1,500 years. It would appear that cottonwood, alder, and some birch have been the dominant vegetation around Tuxedni Bay until recently in geologic terms.

Significant terrestrial faunal resources in the Tuxedni Bay area are somewhat restricted in variety, reflecting the steep coastal terrain, limited hinterland, and generally short, small drainages. The dominant large land animal in the area is the brown bear (*Ursus arctos*). They are numerous and harvest salmon and clams with enthusiasm. A few moose (*Alces alces*) can be found in larger drainage valleys. The nearby Chigmit Mountains are natural habitat for mountain sheep (*Ovis dalli*). Historically, trapping in the general area targeted muskrat, beaver, fox, wolverine, and a few wolves (Stanek et al. 2006).

Several species of salmon spawn in area streams. Most notably, silver and chum salmon spawn in the smaller streams and are present in the streams closest to the Magnetic Island site. Sockeye and chum salmon are present in the Tuxedni River at the head of Tuxedni Bay (Johnson and Blanche 2012). A significant run of sockeye enters Crescent River, bound for Crescent Lake. Harbor seals pursue the salmon in Cook Inlet waters while they travel to their spawning destinations. Clams, primarily razor clams, are very abundant on sandy Cook Inlet beaches. The sandy beaches at Polly Creek are especially productive and support a commercial clam harvest in most years.

CULTURAL CONTEXT

The general culture history for Cook Inlet is based on research from archaeological sites on the Kenai Peninsula and upper Cook Inlet sites. Reger (1998) summarized findings on the northern Kenai Peninsula and Turnagain Arm. Workman (1998) discussed mainly Kachemak Bay research. Both articles identified significant gaps in the archaeological record, particularly during the early and middle Holocene periods. Recent field studies in the Susitna River valley have expanded knowledge about the earlier known cultures (cf. Wygal and Goebel 2012).

A major gap in the culture historical record in Cook Inlet exists during the period from 4000 to 3000 cal BP, at least among the radiocarbon-dated collections. Some have speculated that an early Kachemak Tradition occupation may have occurred during that time (cf. Clark 1997; Workman 1998), but such collections are rare and as yet undated. Other isolated and undated collections may also have been found but remain unrecognized.

Sites dated to the preceding millennium (ca. 5000–4000 BP) are present; for example a site on the upper Kenai River (SEW-00214) that yielded stone projectile points distinguished by notches chipped into the sides near the bases of the points. Two radiocarbon dates of 4640 ± 150 and 4795 ± 165 (4880–5640 and 5050–5900 cal BP)[1] immediately precede the layer containing the notched points (Holmes et al. 1985). The points compare in form and age with material attributed to the Northern Archaic culture in more interior regions of Alaska (cf. Ackerman 2004; Esdale 2008), but little else is known about a possible notched point stage in the general Cook Inlet region.

At essentially the same time as the notched points, sites that contain ground slate and chipped stone artifacts were occupied in Kachemak Bay and Turnagain Arm. Workman (1998) reported a Late Ocean Bay II occupation at the Sylva Site (SEL-00245), radiocarbon dated to about 4500 BP. Ground slate artifacts at the Sylva Site compare very closely with Ocean Bay II collections from Kodiak Island. A small collection from the Beluga Point site (ANC-00054) in component BPS1-2 was associated with two radiocarbon dates, 4155 ± 160 and 4080 ± 150 (4160–5270 and 4150–4960 cal BP) (Reger 1998; Reger and Boraas 1996). The collection contains artifacts very similar to Ocean Bay II (ground slate points) and Arctic Small Tool-related collections (chipped stone bipoint and flake knife). Data about resource use and settlement patterns have not been recovered from these sites.

At a slightly later date, several sites closely comparable to Arctic Small Tool collections from southwest Alaska occur again in Kachemak Bay and Turnagain Arm. The basal component from the Chugachik Island site (SEL-00033) yielded finely chipped stone points and knives very like those of the Gravels Phase material from the base of the Alaska Peninsula. The basal component has been radiocarbon dated at 4005 ± 100 and 4220 ± 110 (4160–4820 and 4430–5040 cal BP) (Workman and Zollars 2002). The more distantly related and undated Beluga Point component BPN-2 contained comparable chipped stone knives (Reger 1981, 1998).

Following the 4000–3000 BP chronological gap, there are numerous sites in Cook Inlet attributed to the Kachemak Tradition (which also occurs on Kodiak Island and along the Shelikof Strait). Kachemak Tradition sites occur in Kachemak Bay and on the central Kenai Peninsula along the Kenai and Kasilof rivers (Reger 1998; Workman 1998). Recently, a Riverine Kachemak occupation has been investigated at the Hewitt Lake site (TYO-00085) near the Yentna River (Dixon 1996). In contrast to sparse archaeological evidence from earlier sites, excavations on Kachemak Tradition sites have yielded considerable data about habitations, settlement patterning and, especially for Kachemak Bay sites, extensive information about resource use. The Kachemak Bay sites have generally been deep middens and did not produce much evidence of houses, probably due to the practice of making trench excavations in the deep deposits. Riverine Kachemak sites do not often contain extensive faunal remains, but have yielded structural information. Houses of the period were semisubterranean, rectangular structures with one main room and a central fire hearth. A single, thin Kachemak Tradition site (ILI-00104) has been located on the west shore of Cook Inlet in Kamishak Bay, approximately 75 km south of Magnetic Island (Klein 1999).

The Kachemak Tradition is characterized by harvest of salmon along the major rivers and of marine resources, such as sea mammals, marine fish, and shellfish in the southern Cook Inlet sites. Kachemak Tradition sites are classified as Riverine Kachemak and Marine Kachemak based on the resources harvested and differences in artifacts used. Marine Kachemak collections feature more organic remains due to the presence of deep shell middens which aid organic preservation. Marine Kachemak sites also contain a much greater percentage of ground slate tools, as opposed to the mostly chipped stone collections in Riverine Kachemak sites. Enough similarities of both ground stone and chipped stone artifact forms exist to consider the sites part of the larger Kachemak Tradition. Artifact similarities also extend to sites in the Kodiak Island and Shelikof Strait areas (Clark 1977). Some chipped stone artifacts in Riverine Kachemak sites appear to reflect influences from the Norton Culture of Southwest Alaska as much as from the more mainstream Kachemak Tradition. Kachemak Tradition sites in Cook Inlet date between 2,500 and about 1,500 years ago. Some Riverine Kachemak sites along the Kenai River appear to last until about 1,000 years ago (Reger and Boraas 1996). (See Fig. 1 for site locations.)

WEST SHORE, LOWER COOK INLET

Formulation of the culture history for Cook Inlet has depended almost exclusively on research on the Kenai Peninsula and in the Matanuska-Susitna area. Few sites have been recorded along the west shore of Cook Inlet south of the forelands where the northern part of Cook Inlet assumes a very different environment. The many recorded sites north of the forelands, with the exception of Beluga Point, Hewitt Lake, and the sites along the middle Susitna River, are virtually all Late Prehistoric Dena'ina sites. Most feature house pits and occasional cache pits.

Sites in the immediate area of Tuxedni Bay include an undated ephemeral site near the entrance to the bay (KEN-00221) (Klingler 1993) and most notably, the Tuxedni Bay Pictograph Site (KEN-00229). The pictograph site is located on the north shore of the Tuxedni River, approximately 24 km west of the entrance to the bay (de Laguna 1975; Griffin 1989). The pictographs in the rock shelter have been analyzed and the associated midden tested (Baird 2006). A radiocarbon date of 450 ± 50 (320–620 cal BP) from a sample taken from the base of the rock wall (J. Schaaf, pers. comm. 2012) places the deposits in the Late Prehistoric period.

SITE EXCAVATION AND RESULTS OF ANALYSIS

Surface features at the Magnetic Island site consist of four ovoid depressions in the ground, measuring approximately 2 to 4 m in diameter, set approximately 2 to 5 m apart (Features 1–4) (Fig. 4). Test pits (TPs, 50 x 50 cm) and excavation units (EUs, 1 x 1 m) placed in all depressions

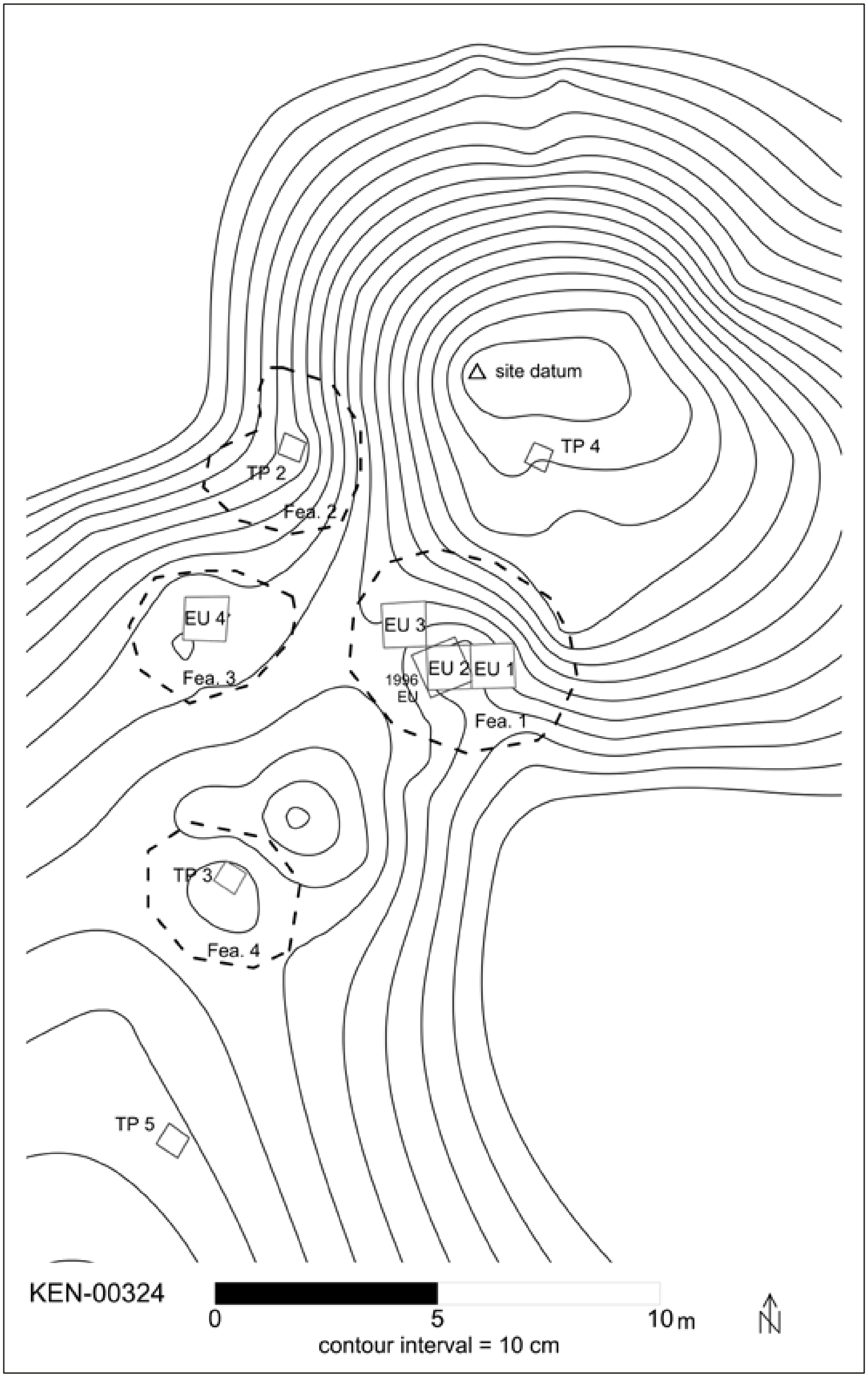

Figure 4. KEN-00324 site map.

confirmed the presence of cultural material in Features 1, 3, and 4. Feature 2 was found to be sterile and was likely formed by natural means. TP 1 was later expanded and became EU 4. The site area, estimated at 125 m^2, was determined by subsurface testing in all visible surface features as well as in outlying areas around the perimeter of the site. In total, four 50 cm^2 tests (all in 2012) and five 1 m^2 excavation units (four in 2012, and one in 1996) have been excavated at the site.

STRATIGRAPHY

Nearly all sediments present in the excavations at KEN-00324 are comprised of aeolian pyroclastic debris of various sizes and colors, due to the site's proximity to both the Redoubt and Iliamna volcanoes. As a result, the stratigraphic history of the site consists of long periods of slow sediment weathering and organic soil (andisol [soils formed in volcanic ash][2]) development punctuated by rapid deposition of volcanic ash (tephra). These ash deposits range in size from small fine-grained falls to larger sandy ashes with cobble-sized pumice and scoria materials. The existence of multiple buried soil horizons between tephra deposits provides evidence for distinct chronological separation between volcanic events.

Cultural materials were encountered between depths of ca. 38 cm below the surface (cm BS) to 85 cm BS. The deepest and densest deposits were encountered in Features 1 and 3, while Feature 4 had thinner and less dense deposits (likely correlating to its location on the site's periphery). Cultural materials were immediately apparent in all positive units at the transition from the very compacted, dark reddish-brown tephra (C3 horizon) to the mottled tephras below (C4–6 horizons). Strata displayed a high degree of correlation across the site area (Fig. 5).

Visible cultural materials consisted of charcoal in varying concentrations, small amounts of fragmented bone, copious amounts of lithic debitage, and occasional lithic tools. Several dense concentrations of charcoal in EUs 1 and 2 were interpreted as likely hearth features (Figs. 5, 6). A box hearth, constructed of small thin slabs of stone, was located on and dug into sterile sediments at the bottom of EUs 1 and 2. Hearth slabs were from 10 to 15 cm in length and 2 to 3 cm thick. The rectangular hearth was shallowly recessed into the occupation surface by approximately 5 to 10 cm. An assemblage of small angular and sub-rounded cobbles, potentially cooking stones (cf. Dumond 1981, 2001) was located immediately adjacent to the box hearth. Cultural strata in EU 3 were somewhat thinner than in neighboring units 1 and 2; this unit was differentiated by large amounts of angular cobbles and even boulder-sized rocks (potentially structural material) (Fig. 7).

FEATURES

Feature 1, the largest depression at the site, yielded cultural deposits in which three separate hearths were superimposed (Fig. 6). The two upper hearths in Feature 1 consisted of some larger, sub-angular rocks, placed around shallow basins filled with fire ashes and burned debris. Crowell (1996) described several of the hearth rocks in the upper hearth as "rock slabs," some placed in vertical position. Flat stones almost covered the entire upper hearth. The hearth deposits of each of the higher hearths contained charcoal, fire-cracked rocks, and a few very poorly preserved fish bones. The fish bones were mostly ribs, with a few apparent jaw or skull bone fragments that were not recoverable. The size of the bones suggests the fish were salmon. Several pieces of bark, either birch or alder, were found under rocks in the middle hearth.

The lowest hearth, uncovered during 2012, was a box arrangement constructed of stone slabs and filled with charcoal and burned sediment. Immediately on top and to the side of the hearth feature was a large pile of burned, round stones. The stones likely were used in stone boiling and discarded beside the hearth. The box hearth and the overlying hearths appear to have been placed very close to the north wall of the depression. More extensive excavations would be required to ascertain whether the feature was a long-term, semisubterranean habitation structure or a temporary structure, such as a wind break or tent depression.

Box hearths of the form recorded at KEN-00324 are also found in Gravels Phase sites along the Brooks River on the Alaska Peninsula. Dumond (1981:125) illustrated a box hearth in house feature 1 at the BR-16 site that appears nearly identical, complete with associated burned boiling stones. Dumond (2001) more recently suggested that box "hearths" are more likely structures, perhaps holding skin or bark containers, associated with stone boiling. He concluded that as a diagnostic of the Gravels Phase, the presence of boiling stones associated with the box structures was more significant than the structure itself. The piece of bark found in the middle hearth in

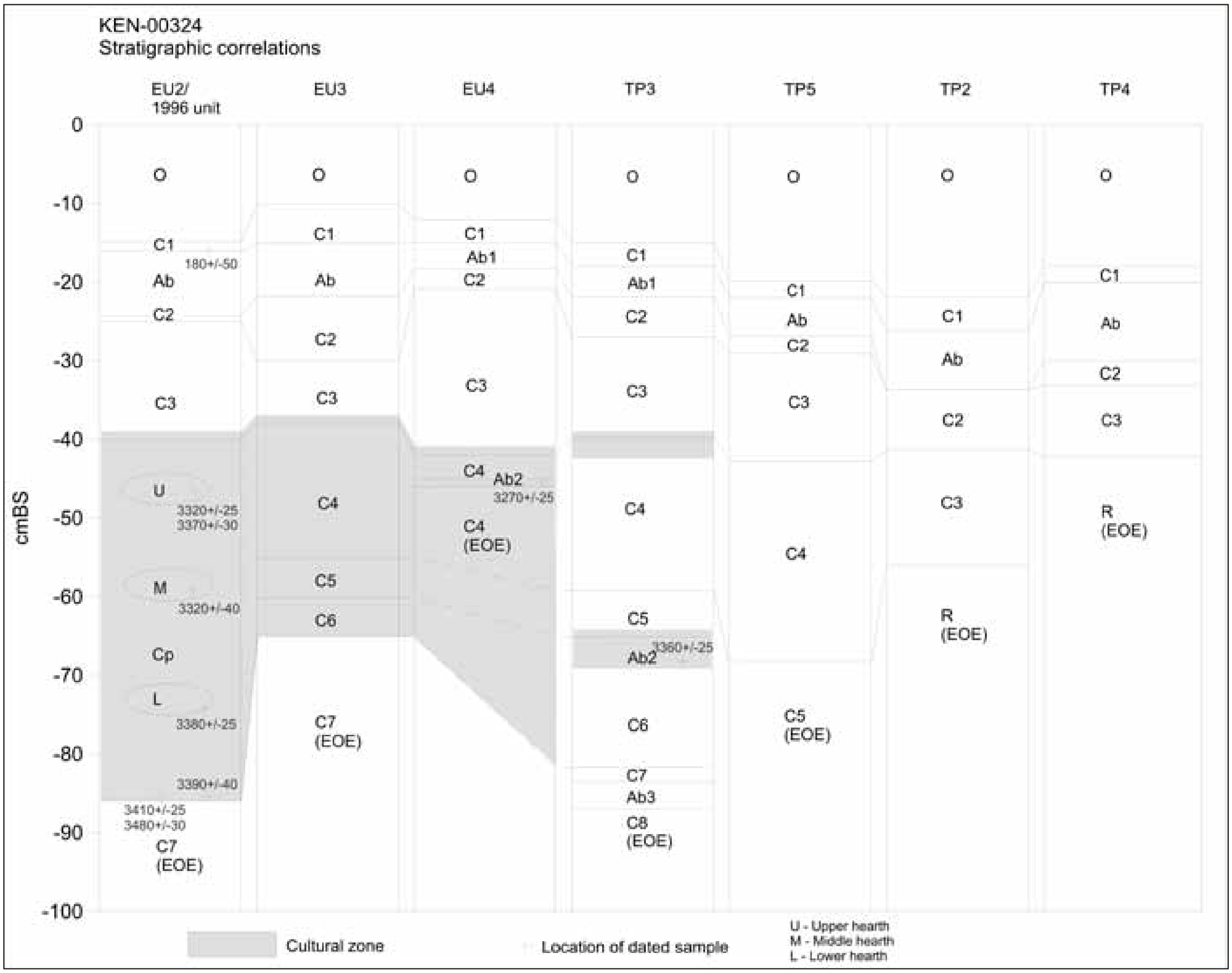

Figure 5. Stratigraphic correlations for all excavation units (EUs) and test pits (TPs). Key: Ab = organic-rich sandy silt tephra; Ab2 = organic-rich silt; Ab3 = organic-rich silt. C1 = silty tephra; C2 = silty sand tephra; C3 = silty tephra; C4 = silt, minor sandy tephra; C5 = silty tephra; C6 = silty sand tephra; C7 = silty tephra; C8 = sandy tephra. EOE = end of excavation; O = vegetation and decomposed organics.

Feature 1 at the Magnetic Island site may add support to Dumond's theory about the function of bark-lined box hearth structures. The Brooks River hearths were located within "relatively permanent settlements," serving as central bases for seasonal movement (Dumond 1981). Rectangular slab hearths were uncovered in late Ocean Bay II deposits at the Rice Ridge Site (KOD-00363) on Kodiak Island in a level associated with a radiocarbon date of 3860 ± 90 BP (4070–4450 cal BP) (Hausler 1991). Steffian and Saltonstall (2005) report a box hearth from an Early Kachemak house at the Zaimka Mound Site (KOD-00013) on Kodiak Island dated to 3500 ± 80 BP (3570–3980 cal BP).

DATING

Twelve radiocarbon ages have been produced on charcoal samples recovered from cultural and geologic contexts at the Magnetic Island site (five from 1996[3] and seven from 2012) (Table 1). Of these, nine ages were accelerator mass spectrometry (AMS) assays, and three were conventional radiocarbon dates.

Results of dating analysis suggest a continuous occupation of the Magnetic Island site from ca. 4080 to ca. 3380 cal BP. However, several determinations appear to be stratigraphically inconsistent or are out of chronological sequence. The two dates with the largest standard deviations

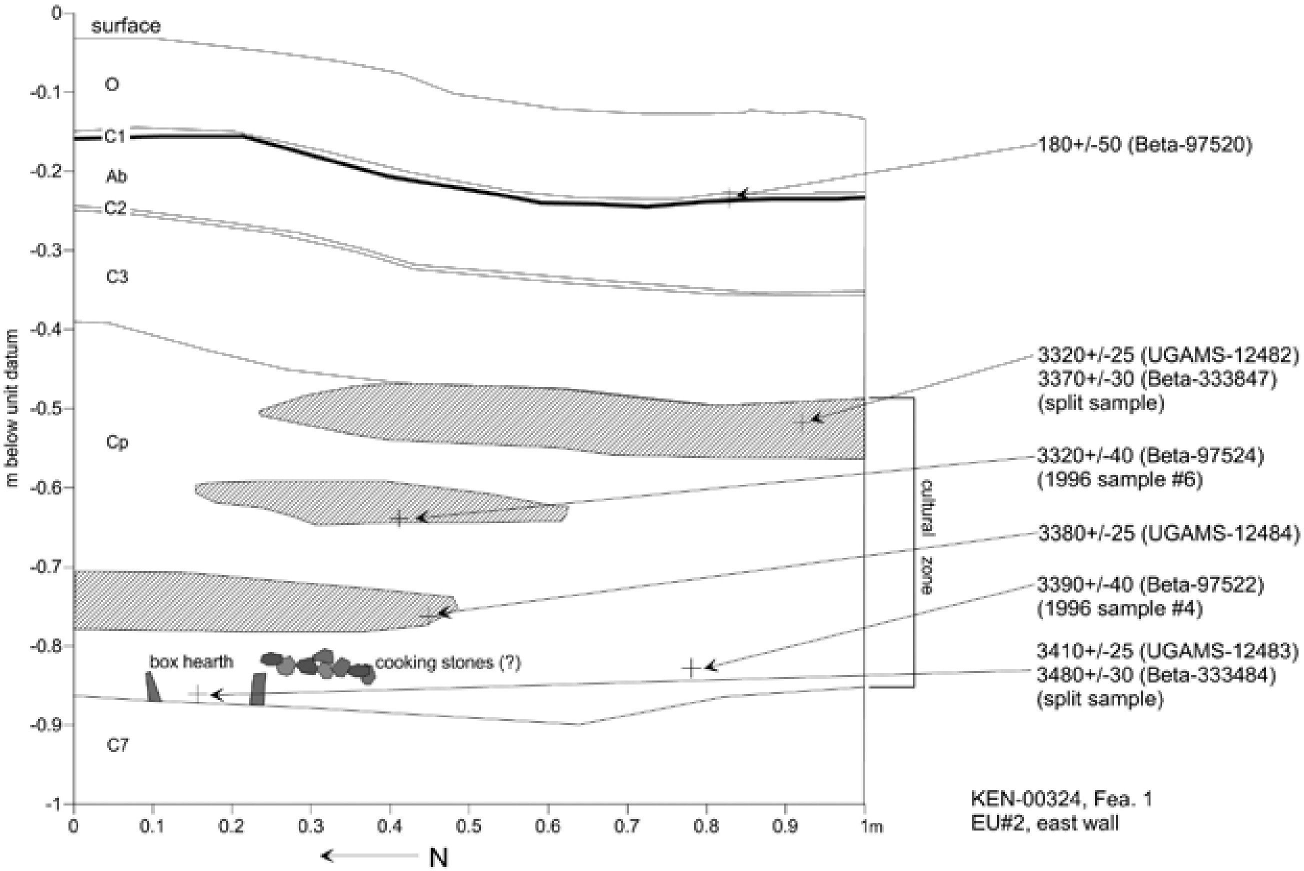

Figure 6. Location of dated samples on stratigraphic profile of EU 2.

Figure 7. Large, angular cobbles in EU 3, Feature 1.

(Beta-97521 and Beta-97523) both appear out of sequence when compared with the other determinations. For purposes of this investigation, therefore, a higher-resolution chronology was developed using only AMS results, with standard deviations of ± 40 years (or less). Using the nine results that meet these criteria, all determinations appear in chronological sequence, and eight of the nine overlap at two standard deviations (2σ) (Fig. 8). With these results, the Magnetic Island occupation is dated from ca. 3840 to 3440 cal BP, a period of around 400 years.

The oldest dates in the refined chronology come from the box hearth located in Feature 1. The two dates from a single split sample (3410 ± 25 BP and 3480 ± 30 BP) provide a range from 3840 to 3580 cal BP) (Fig. 9). A stratigraphically equivalent sample from the 1996 excavation provided a date of 3390 ± 40 BP (3820–3490 cal BP), nearly identical to a sample from the charcoal concentration overlying the box hearth (3380 ± 25 BP, 3690–3570 cal BP). The youngest dates in the refined AMS sequence come from samples taken from the uppermost cultural levels: 3270 ± 25 BP from EU 4, and 3320 ± 25 BP from EU 1 (3570–3440 cal

Table 1. Radiocarbon dating results from KEN-00324 samples. Calibrated using CALIB 6.1 (Stuiver et al. 2005) and the INTCAL09 terrestrial calibration model (Reimer et al. 2009).

Lab Number	Provenience	Method	Conventional Age BP	cal BP (cal AD/BC) (2σ)
Beta-97520	1996 unit, 18 cm BS	conventional	180 ± 50	0–300 (cal AD 1650–1950)
Beta-97521	1996 unit, 30–40 cm BS	conventional	3440 ± 140	3380–4080 (cal BC 2130–1440)
Beta-97522	1996 unit, 54 cm BS	AMS	3390 ± 40	3490–3820 (cal BC 1870–1540)
Beta-97523	1996 unit, 40 cm BS	conventional	3500 ± 90	3510–4070 (cal BC 2130–1560)
Beta-97524	1996 unit, 60 cm BS	AMS	3320 ± 40	3450–3680 (cal BC 1730–1500)
Beta-333847	2012 EU 1, 53 cm BS	AMS	3370 ± 30	3490–3690 (cal BC 1740–1540)
UGAMS-12482	2012 EU 1, 53 cm BS	AMS	3320 ± 25	3470–3630 (cal BC 1680–1530)
Beta-333848	2012 EU 2, 86 cm BS	AMS	3480 ± 30	3640–3840 (cal BC 1890–1700)
UGAMS-12483	2012 EU 2, 86 cm BS	AMS	3410 ± 25	3580–3720 (cal BC 1770–1630)
UGAMS-12484	2012 EU 2, 79 cm BS	AMS	3380 ± 25	3570–3690 (cal BC 1740–1620)
UGAMS-12485	2012 TP 3, 66 cm BS	AMS	3360 ± 25	3490–3690 (cal BC 1740–1540)
UGAMS-12486	2012 EU 4, 45 cm BS	AMS	3270 ± 25	3440–3570 (cal BC 1620–1490)

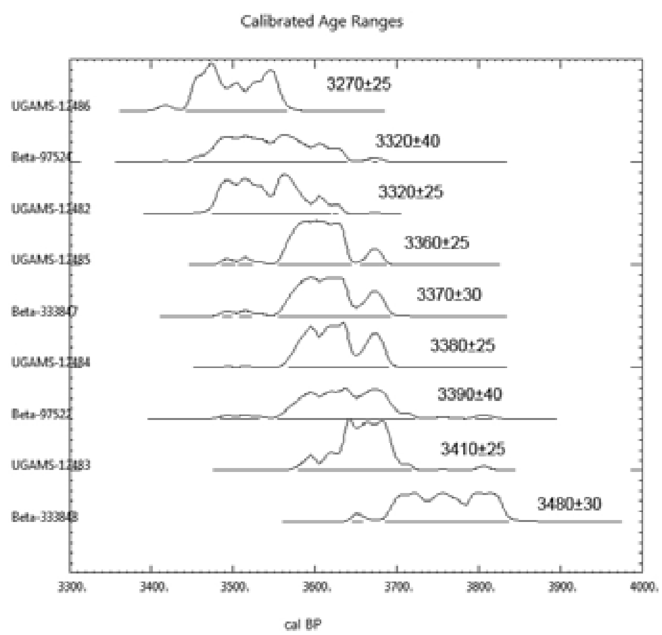

Figure 8. Calibration probability plots for radiocarbon dates with standard deviations of ± 40 years or less.

BP and 3630–3470 cal BP; the latter was a split sample also dated to 3370 ± 30 BP, 3690–3490 cal BP).

TEPHRA ANALYSIS AND CHRONOLOGY

Laboratory analysis of tephra samples collected at KEN-00324 is currently being conducted in cooperation with the U.S. Geological Survey, Alaska Volcano Observatory in Anchorage. Initial assessments based on microscope observation of samples are provided in Table 2.[4] The extremely compact dark reddish-brown tephra (C3 horizon) that caps cultural strata across the site has been preliminarily sourced to the Redoubt Volcano.

Five radiocarbon dates were produced on charcoal samples from EU 2 and one from TP 3 that can be used to determine the relative ages of tephra fall events at the site (Table 3).

The box hearth in EU 2 at around 85 cm BS overlies the interface between a homogenized Cp horizon and C7 horizon, a dark yellowish-brown sandy tephra, providing two relative minimum dates of 3410 ± 25 BP (3580–3720 cal BP, UGAMS-12483) and 3480 ± 30 BP (3640–3840 cal BP, Beta-333848) on the C7 horizon tephra fall event.

Dates produced from the cultural zone hearth sequence in EU 2 overlap significantly, suggesting a relatively continuous occupation. Sediments from this stratum in EU 2 are described as mottled tephras (Cp horizon) and are thought to be an anthropogenic homogenization of the C4, C5, and C6 horizon tephras, which are separate and distinct at other locations throughout the site. Due to this homogenization, these three tephra horizons cannot be accurately separated in EU 2 by dates provided by any of the four hearths within the sequence. However, a culturally derived charcoal layer is present within TP 3 at 65–70 cm BS, underlying the well-sorted yellowish-brown silty C5 horizon tephra and overlying the well-sorted dark brown silty sand C6 horizon tephra with a date of 3360 ± 25 BP (3490–3690 cal BP, UGAMS-12485) fitting within EU 2's tightly dated cultural zone spread. Separation and

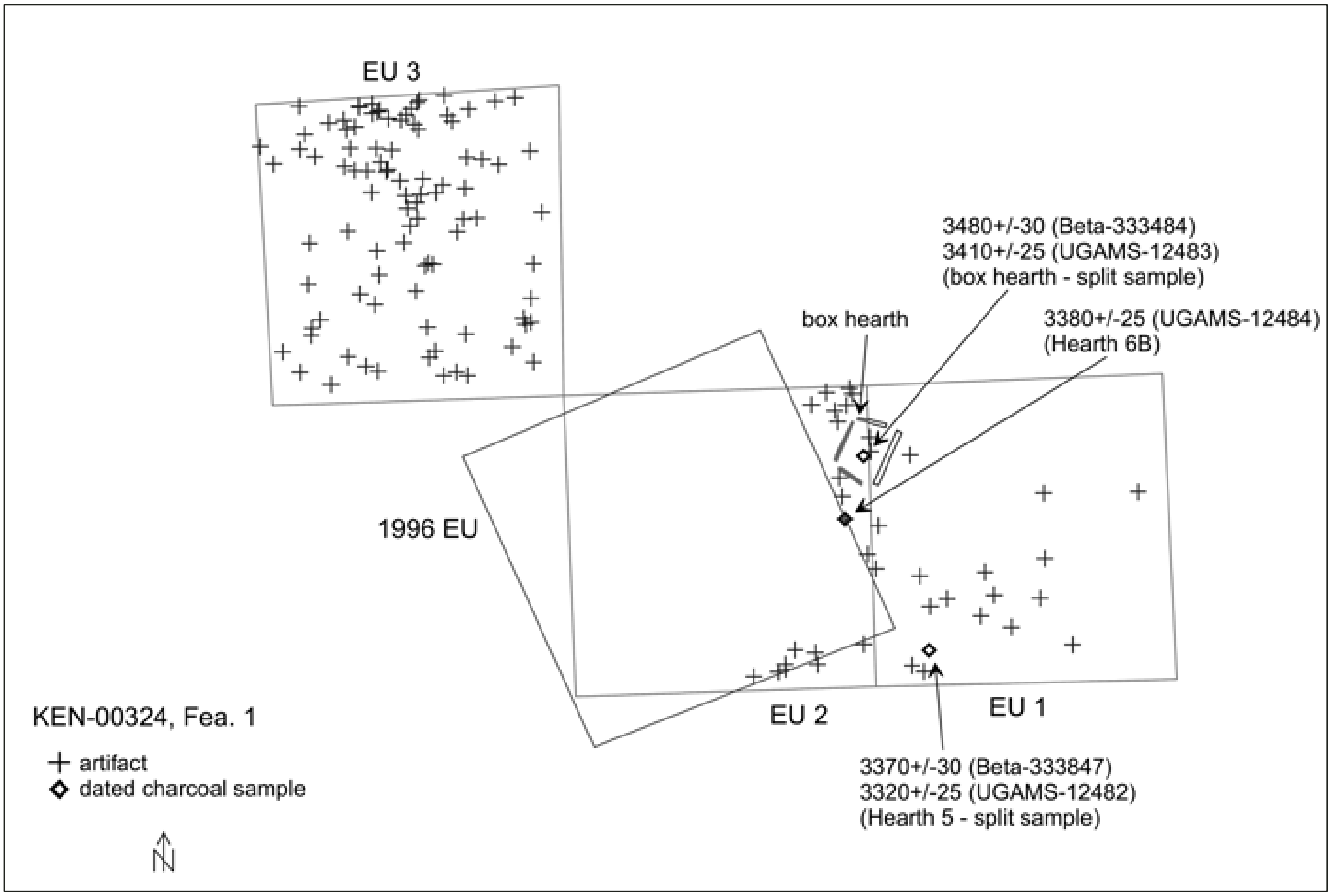

Figure 9. Location of dated samples taken in 2012 from Feature 1.

Table 2. Preliminary source analysis of KEN-00324 tephra samples.

Lab No.	Provenience	Sample description	Possible Source Volcano
AT-2774	1996 unit, L4	Cream pumices	Redoubt
AT-2775	TP3, 34 cm BS, C3 hoz	Cream pumices	Redoubt
AT-2776	EU3, 30–35 cm BS, C3 hoz	Cream pumices	Redoubt
AT-2777	EU3, 65–70 cm BS, C5/6/7 hoz	Dark gray dull pumices with abundant coarse plutonic lithics	Iliamna?
AT-2778	EU3, 60 cm BS, C5/6 hoz	Cream pumices, large lithics, dense gray lithic variety	Redoubt
AT-2779	EU3, 45–47 cm BS, C4 hoz	Cream pumices, abundant biotite, some lithics	Hayes?
AT-2780	EU3, 55–57 cm BS, C4 hoz	Cream pumices, abundant clumps of organics, charcoal (?)	Redoubt?
AT-2781	EU3, 8–10 cm BS, O/C1 hoz	Dirty white pumices, abundant clumps of organics, charcoal (?); resembles AT-2784, 2786, 2787	?
AT-2782	TP3, 12 cm BS, O/C1 hoz	Fine-grained white pumice with dense gray lithics; same as AT-2788	Augustine?
AT-2783	TP3, 40 cm BS, C3/4 hoz	Cream pumices, 1.3 cm granite clasts; few large pumices 0.9 and 0.8 cm	Local source
AT-2784	TP3, 24 cm BS, C2 hoz	Resembles AT-2781, 2786, 2787	?
AT-2785	1996 unit, L8	Bright white pumices	Augustine?
AT-2786	1996 unit, L3A	Resembles AT-2781, 2784, 2787	?
AT-2787	1996 unit, L3	Resembles AT-2781, 2784, 2786	?
AT-2788	1996 unit, L2	Fine-grained white pumice with dense gray lithics; same as AT-2782	Augustine?

Table 3. Radiocarbon results related to tephra dating from KEN-00324 samples.

Lab Number	Provenience	$^{13}C/^{12}C$ (per mil)	Conventional Age BP	cal BP (cal AD/BC) (2σ)
Beta-333847	2012 EU 1, 53 cm BS	–25.3	3370 ± 30	3490–3690 (1740–1540 cal BC)
UGAMS-12482	2012 EU 1, 53 cm BS	–25.7	3320 ± 25	3470–3630 (1680–1530 cal BC)
Beta-333848	2012 EU 2, 86 cm BS	–23.5	3480 ± 30	3640–3840 (1890–1700 cal BC)
UGAMS-12483	2012 EU 2, 86 cm BS	–25.0	3410 ± 25	3580–3720 (1770–1630 cal BC)
UGAMS-12485	2012 TP 3, 66 cm BS	–23.9	3360 ± 25	3490–3690 (1740–1540 cal BC)

lack of homogenization of sediments may occur in TP 3 because of its location at the periphery of the site locus where cultural lenses are thinner, with less anthropogenic sediment alteration.

The EU 2 C3 horizon is a well-sorted dark brown silty sand tephra present at approximately 25–45 cm BS, with a thickness of 20 cm. Two dates were produced for the upper hearth feature present within the C4 horizon, overlying the C3 horizon, with dates of 3320 ± 25 BP (3470–3630 cal BP, UGAMS-12482) and 3370 ± 30 BP (3490–3690 cal BP, Beta-333847). These dates provide a maximum age for the C3 horizon tephra event. The C3 tephra has been provisionally sourced to the Redoubt Volcano.

Horizon C1 in EU 2 is a well-sorted gray silty tephra present between 15–20 cm BS, with a thickness of 3–5 cm, provisionally sourced to the Augustine Volcano. Just underlying this layer is a 15-cm-thick buried, very dark brown, organic-rich soil developed in a volcanic ash (andisol; Ab horizon). A charcoal sample was collected from the interface between these two strata, which provides an ultimate maximum date of 180 ± 50 BP (0–300 cal BP, Beta-97520, from 1996) on the overlying C1 horizon tephra event. This same andisol provides a relative minimum date on the underlying C2 horizon tephra below. C2 is a 2–3 cm thick dark brown silty tephra.

ARTIFACT ANALYSIS[5]

Lithic Materials and Artifacts

Lithic material types found within the KEN-00324 site area include basalt, chalcedony, chert, jasper, magnetite, quartz, an unidentified white fine-grained metamorphic material, and variously colored fine-grained granitic materials (Table 4). Granitic materials dominate the lithic assemblage.

Mapped surficial geology within 20 km of Magnetic Island displays an abundance of both igneous and sedimentary raw materials suitable for knapping stone tools. Some outcrops are located on Magnetic Island itself; however, no microcrystalline quartz-structured sedimentary rocks (chert or chalcedony) are mentioned in the geologic literature referring to the area (Wilson et al. 2009). Chalcedony and chert make up 0.63% and 5.26%

Table 4. Raw material types from the KEN-00324 lithic assemblage.

Rock Type	Description
basalt	Black, brown, or green in color; fine- to medium-grained texture; low luster; mostly homogenous in mineral matrix with minor quartz crystal growth.
chert	Colors ranging from white to light greenish-gray to dark bluish-gray; medium luster; fine-grained texture; some abrasion on dorsal surfaces caused by water wear indicative of stream or river pebbles and cobbles.
granitic material	Mostly pale brown and light greenish-gray, some white and black; low luster; macroscopically visible medium- to coarse-grained crystal texture; some alteration in texture and patina of dorsal surfaces from chemical weathering.
quartz	Clear to opaque white; high luster; high incidence of visible inclusions; some abrasion on dorsal surfaces caused by water wear indicative of stream or river pebbles and cobbles.
unknown	White; low to medium luster; medium-grained texture.
chalcedony	White and black, sometimes with alternating yellowish and clear laminations; high luster; fine-grained texture.
magnetite	Gray to black; medium to high luster; medium-grained texture; reacts with hand compass; some abrasion on dorsal surfaces caused by water wear indicative of stream or river pebbles and cobbles.
jasper	Red to dusky red; medium to high luster; fine-grained; mostly homogeneous with some darker and clear laminations and inclusions.

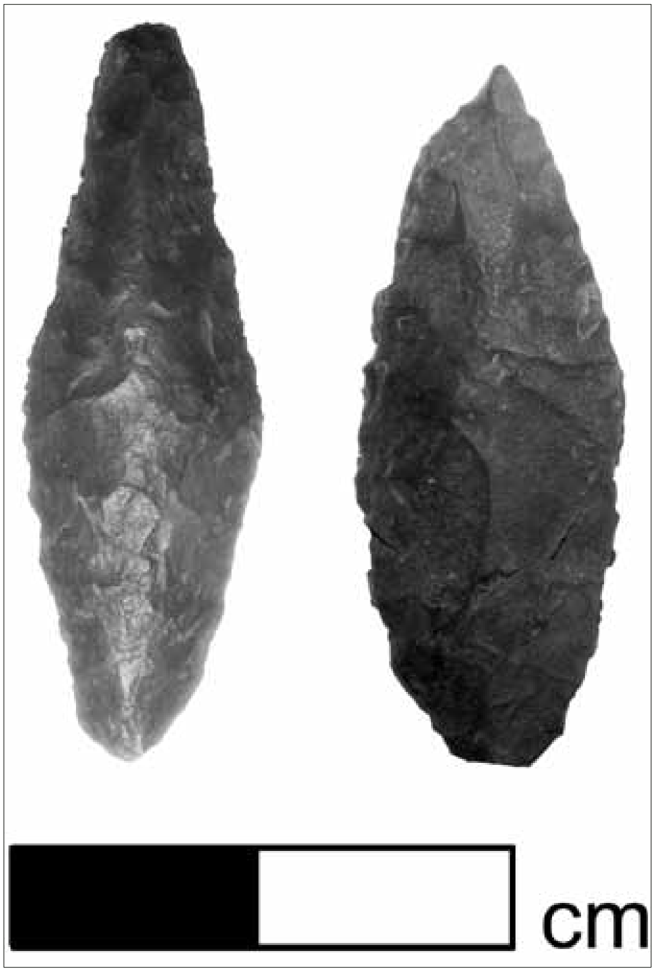

Figure 10. Bipoints (cat. nos. LACL 093-8107 and 417-7970).

of the total lithic assemblage respectively. Granitic materials are by far the most abundant material among all features, with an overall concentration of 74% by tool and debitage count and 83% of total weight. Several strategies were being used to reduce lithic materials, including hard hammer, soft hammer, and pressure flaking, indicating an apparent focus on bifacial reduction techniques (Andrefsky 1998).

The abundance of granitic materials is likely due to the close proximity of corresponding outcrops in the area and prehistoric occupants' ability to obtain and move larger package sizes of this locally abundant material back to their camp sites and living areas. Furthermore, these granitic materials consist of larger crystals (olivine, hornfels, and quartz) and do not flake as cleanly as microcrystalline materials such as cherts and chalcedonies. The granitic materials likely would not have been preferred over more microcrystalline types of raw materials in areas where these more knappable materials are abundant.

A total of 2,243 pieces of debitage were recovered from KEN-00324. The majority of debitage ranges in size from 10 to 30 mm with an average of 16 mm. A higher degree of incomplete flake fragments (proximal, medial, and distal) are present than complete flakes. Despite significant flake fragmentation, no particular flake portion dominates the assemblage. This suggests that debitage breakage may be a result of post-depositional processes such as bioturbation, cryoturbation, or human trampling during occupation.

The artifacts recovered at KEN-00324 are predominantly flaked lithic pieces and flaking debris. Several grinding slab fragments were recovered and probably were used for grinding red ochre, pieces of which were also found in the site. In fact, *lack* of slate or extensive stone grinding is considered a distinguishing trait of the total collection from KEN-00324, especially significant for the period to which the collection has been dated.

Chipped Bipoints

Two bifacially flaked points were recovered from the site, one (LACL 093-8107) found in Feature 1 during 1996 and the second (LACL 417-7970) recovered from Feature 3 in 2012 (Fig. 10). The first bipoint is small, 2.63 cm in length, made from a flake blank. The ventral surface shows slightly invasive irregular and collateral fine flaking. The original ventral surface of the flake blank is still evident. The second bipoint is a complete, finely finished piece, 2.96 cm in length. It is collaterally flaked with fine edge retouch and is widest at its longitudinal midsection. The cross-section is lenticular. One tip of the point tapers more than the opposite, more convex tip. The tapered tip has slight grinding along the lateral margins and hinge-fractured flake removals at the tip's edge, which may indicate that this end was inset into a composite point. The more roughly flaked piece is a form that occurs in many cultural phases in southern Alaska over a wide span of time. The more finely finished bipoint very closely resembles small bipoints or endblades that occur in Arctic Small Tool tradition (ASTt) collections and early Norton Tradition collections.

Specifically, the finished stone endblade or bipoint from KEN-00324 very closely resembles bipoints described by Dumond (1981:203) as Bi-point I (Class 29). The bipoints are found in a Brooks River Gravels context of the Arctic Small Tool tradition. A nearly identical bipoint was also recovered from an apparent house at ILI-00002, the Igiugig Airport site (Holmes and

McMahan 1996). A radiocarbon date of 3350 ± 60 BP (3450–3720 cal BP) was obtained from the hearth in the shallow house feature. Farther out the Alaska Peninsula, in the Ugashik Hilltop Phase, somewhat similar bipoints occur but are slightly different in the treatment of the point base (Henn 1978). Henn considered Hilltop Phase material to be ASTt-related but also noted the small points (Types 10, 12) were very like later Norton points (Henn 1978:81).

Small, well-chipped bipoints occur in the Pedro Bay site (ILI-00001) in what has been called the second or later component (Reger and Townsend 1982, 2004). That component is poorly dated and compares to both ASTt and Norton collections in the Bristol Bay area. Two sites on Telequana Lake (XLC-00133 and XLC-00033) also produced similar artifacts. A small contracting stem projectile point and very small sideblade from XLC-00033 both suggest an affiliation with either the ASTt or Norton tradition (Tennessen 2006). A radiocarbon date of 3660 ± 40 BP (3870–4090 cal BP) was obtained from the site, although the excavator cautioned that the charcoal sample could not be definitively associated with the artifacts (Tennessen, pers. comm. 2012).

Similar small bipoints also occur on Kodiak Island in contexts considered to be Ocean Bay II (Hausler 1991). A finely chipped chalcedony bipoint from the Rice Ridge site has been cited as an example of Arctic Small Tool implements on Kodiak Island (Hausler 1991; Steffian and Saltonstall 2005). Hausler noted the point and other bipoints were associated with a radiocarbon date of 3850 ± 80 BP (4070–4440 cal BP).

The basal component at the Chugachik Island site, SEL-00033, contains small, finely chipped bipoints but radiocarbon dating for the collection places it in excess of 4000 ^{14}C years BP (Workman and Zollars 2002). That component contains many other artifacts diagnostic of an Arctic Small Tool tradition occupation not present in the KEN-00324 collection, and it predates the KEN-00324 occupation by 400 to 500 years.

Chipped Adzes

Examples of thick, chipped bifaces, thought to be broken adzes, were found in Features 1 and 3 (Fig. 11). All were chipped from light greenish-gray igneous material. The adzes appear to fit closely with Dumond's description of Type IV adzes of the Gravels Phase at Brooks River. Adze IV forms also occur in the Norton phases following the Gravels Phase (Dumond 1981). One fragment exhibits a ground and polished surface, similar to those illustrated by Dumond (1981). Chipped adze bits of similar form are *not* described from Ocean Bay II or Early Kachemak on Kodiak Island.

Grinding Stone or Whetstone

A possible whetstone fragment from the Magnetic Island site has very limited diagnostic value, as whetstones occur in many collections of widely varied ages in the region. The noteworthy trait of the Magnetic Island specimen is the red ochre stain on the grinding surface. The fragment from Feature 1 was associated with the middle hearth, which was found at the same level as red ochre stains and fragments (Fig. 6).

Similar whetstones, likely associated with red ochre, occur in Gravels and later Weir phases at Brooks River (Dumond 1981). Dumond classified these as Whetstone II, variety 1. Whetstones also occur in the lower component of the Pedro Bay site, but would be several hundred years older than the Magnetic Island specimen (Reger and Townsend 2004). Red ochre also occurs in the lower component deposits at the Pedro Bay site.

WOOD, BARK, AND BONE

Wood

Speciation analysis was undertaken on 15 samples of woody fragments, twigs, and charcoal obtained from EU 2 and TP 3. Three samples could not be identified. Of the remainder, 11 were identified as *Populus* (cf. *deltoidea trichocarpa*), or black cottonwood, with one possible *Populus tremuloides* (quaking aspen).[6]

Bark

Five pieces of tree bark were recovered from the site during the 1996 excavation. Based on visual inspection, all bark fragments are provisionally identified as either birch or alder. All pieces were collected from beneath rocks in the Feature 1 middle hearth.

Bone

Bone residues were observed in the upper hearths of Feature 1 during excavation; possible fish ribs and a few apparent fish jaw or skull bone fragments were not recoverable. Bulk samples taken from charcoal concentrations

Figure 11. Bifaces (cat. nos. LACL 417-7997, -7956, -7876, and -7954).

were wet-sieved during laboratory analysis, resulting in the recovery of a small amount of calcined bone fragments. These fragments were also determined to be fish, although speciation was not possible.[7]

DISCUSSION

Data presented above suggest the clear affinity of material from the Magnetic Island site with that from other sites in the region attributed to the Arctic Small Tool tradition. The presence of ASTt-related material has been documented at numerous sites in southcentral and southwestern Alaska, although few have been securely dated (cf. Slaughter 2005). Prior to the Magnetic Island investigations, the Chugachik Island site in Kachemak Bay was the only securely dated ASTt site on Cook Inlet, at 4150–5040 cal BP somewhat older than similar sites from farther south and west. Dates from ASTt sites on the northern Alaska Peninsula and the lakes of the southern Alaska Range are summarized in Fig. 12. These data suggest a fairly consistent time period for ASTt occupation in the region of roughly 1,700 years, from 3,300 to 5,000 years ago.

Based on the dates from Chugachik Island, Workman and Zollars (2002) suggest a dispersal of the Arctic Small Tool tradition southward from Bering Strait by at least ca. 4,000 radiocarbon years ago, arriving in the Kenai Peninsula prior to the Alaska Peninsula. By around 3,800 radiocarbon years ago, ASTt people were present on the Bering Sea side of the Alaska Peninsula, quickly moving inland along the region's major rivers (Dumond 2005).

Many questions remain, particularly the origin of the ASTt on Cook Inlet and the relationship between Magnetic Island and other sites in the region. Given the disparity in dates, it seems more likely that the Magnetic Island site occupation is more closely related to those on the Alaska Peninsula than to that at Kachemak Bay. In one scenario, a two-pronged movement south from Bering Strait might be envisaged, with an earlier stream of ASTt crossing the Alaska Range, perhaps leaving traces in deep interior contexts such as

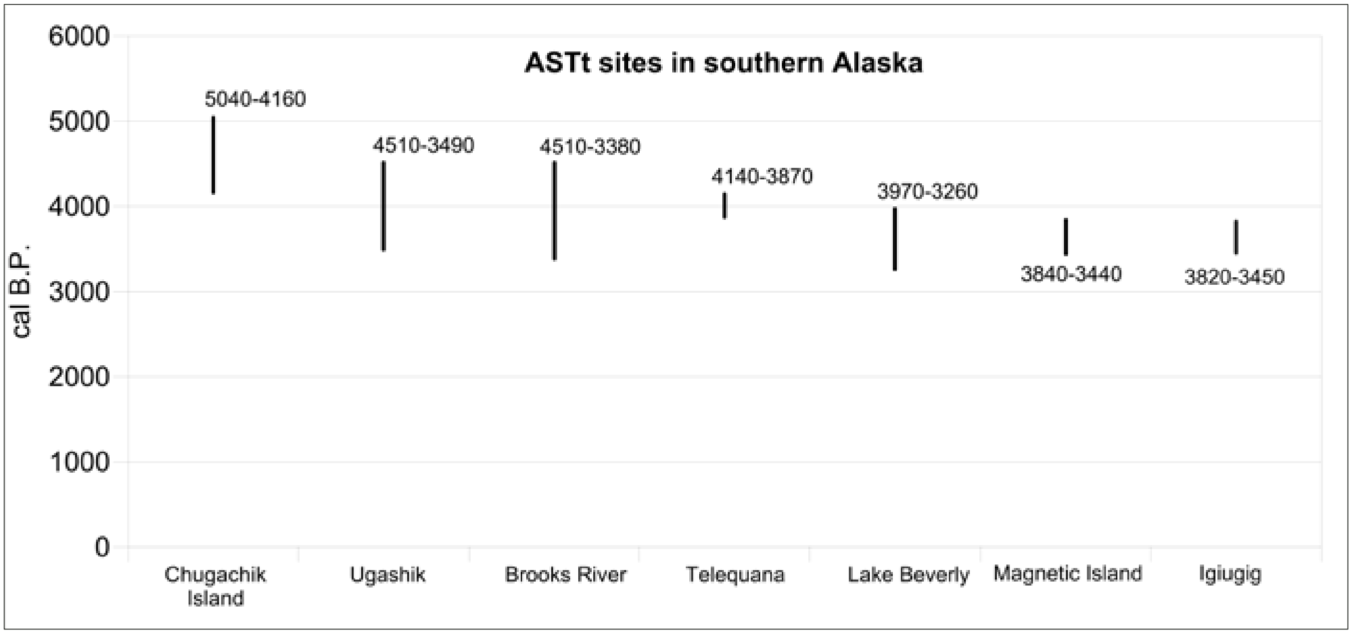

Figure 12. Calibrated date ranges for ASTt sites in southern Alaska.

Tyone Lake (cf. Irving 1957), and eventually ending on the Kenai Peninsula. The second movement would have passed south through the Yukon–Kuskokwim Delta to Bristol Bay and the Alaska Peninsula, although as noted by Workman and Zollars (2002), Shaw (1982), and others, the distributional gap clearly requires further survey work in the delta region. However, a more likely scenario involves initial southerly migration followed by multiple movements north and east from the Alaska Peninsula, resulting in the various sites on Cook Inlet. In any case, occupations to the west of Cook Inlet still provide a more enduring record, as large and stable salmon runs along drainages such as the Brooks River enticed the ASTt people "to settle in a more sedentary fashion than they had been accustomed to" (Dumond 2005:75). A similar resource base must be considered for Magnetic Island, where the only faunal remains (poorly preserved) appear to be fish bones.

Investigations of ASTt occupations in the Brooks River area revealed that a hiatus of as much as 500 years can be seen in the cultural chronology of that area. Dumond (2011) believes the Brooks River and nearby areas were abandoned during the time between the ASTt and Norton occupations. Impacts to caribou herds and anadromous fish runs on the Alaska Peninsula by a number of large volcanic eruptions during the fourth millennium BP (such as Aniakchak, Veniaminof, and others, cf. Miller and Smith 1987; Begét et al. 1992) certainly affected human populations in the region (Dumond 2005; Vanderhoek 2009). Similarly, the Redoubt tephra capping cultural levels at KEN-00324 suggests that volcanism was a major factor in the cessation of human occupation at the Magnetic Island site.

Research by Vanderhoek (2009) and others has shown that Alaska felsic tephras may lay exposed for a relatively long period of time following a depositional event before a soil begins to develop (in some cases taking more than 100 years to develop weak soil horizonation). Revegetation can be slow after volcanic ash deposition, due to factors including soil moisture, temperature, and texture of the tephras. Workman (1979) noted that even thin tephra falls can have severe short-term impacts, such as ejection of poisonous gases and breakage and stunting of plants, damaging the ecosystem and causing lung, eye, and skin problems in animals and people. Under such circumstances it is highly unlikely that people would have remained in the area during thick ash-fall events. Occupants may have chosen to abandon the site, potentially returning after the event, resulting in a temporary hiatus in occupation. This may account for the thickness and disturbance of deposited tephra layers within and between features at the site, despite the relatively short passage of time and nearly continuous presence of lithic artifacts.

The Magnetic Island site collection provides firm evidence that bearers of the ASTt migrated into Cook Inlet during the latter half of the second millennium BC. The collection demonstrates that ASTt influences appearing in Kachemak Bay by 4100 ^{14}C years BP lasted, at least intermittently, in the region until 3400 ^{14}C years ago. The collection also provides a link in time to probable continuing influences in the succeeding cultures of upper and middle Cook Inlet. The period around 3,500 years ago witnessed heightened volcanic activity throughout the Chigmit Mountains and west along the Alaska Peninsula. The burial of the Magnetic Island site occupation may represent an example of what terminated the spread of Arctic Small Tool tradition people into the Cook Inlet basin. Elements of ASTt technology appear to persist among later Cook Inlet cultures (Norton and perhaps Riverine Kachemak), but the complete cultural complex did not.

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ENDNOTES

1. All radiocarbon dates are presented here as age ranges calibrated to two standard deviations (2s). Age determinations were calibrated using CALIB 6.1 software (Stuiver et al. 2005) and the INTCAL09 terrestrial calibration model (Reimer et al. 2009).
2. Sediment and soil descriptions follow national conventions established by the USDA (1993), and slightly modified for soil stratigraphy by Holliday (2004).
3. We thank Aron Crowell for providing radiocarbon dating information from the 1996 testing.
4. Preliminary examinations of tephra samples were undertaken by Kristi Wallace of the Alaska Volcano Observatory.
5. Artifactual materials will be curated at National Park Service administrative headquarters, Anchorage.
6. Wood speciation was undertaken by Owen Davis, University of Arizona Palynology Laboratory.
7. Faunal analysis was performed by Carol Gelvin-Reymiller, NLUR.

REFERENCES

Ackerman, Robert A.
2004 The Northern Archaic Tradition in Southwestern Alaska. *Arctic Anthropology* 41(2):153–162.

Ager, Thomas
2000 Postglacial Vegetation History of the Kachemak Bay Area, Cook Inlet, South-central Alaska. In *Geologic Studies in Alaska by the U.S. Geological Survey, 1998*, pp. 147–165. Edited by K. D. Kelly and L. P. Gough. U.S. Geological Service Professional Paper no. 1615. U.S. Government Printing Office, Washington, DC.

Ager, Thomas, and J. D. Sims
1984 Postglacial Pollen and Tephra Records from Lakes in the Cook Inlet Region, Southern Alaska. *U.S. Geological Survey Circular* 868:103–105.

Andrefsky, William
1998 *Lithics: Macroscopic Approaches to Analysis*. Cambridge University Press, Cambridge.

Baird, Melissa F.
2006 Frederica de Laguna and the Study of Pre-contact Pictographs from Coastal Sites in Cook Inlet and Prince William Sound, Alaska. *Arctic Anthropology* 43(2):136–147.

Begét, James E., Owen K. Mason, and Patricia Anderson
1992 Age, Extent and Climatic Significance of the c. 3400 BP Aniakchak Tephra, Western Alaska, USA. *The Holocene* 2:51–56.

Begét, James E., and C. J. Nye
1994 Postglacial Eruption History of Redoubt Volcano. *Journal of Volcanology and Geothermal Research* 62(1–4):31–54.

Clark, Donald W.
1997 *The Early Kachemak Phase on Kodiak Island at Old Kiavak*. Archaeological Survey of Canada, Mercury Series no. 155. Canadian Museum of Civilization, Ottawa.

Clark, Gerald
1977 Archaeology on the Alaska Peninsula: The Coast of Shelikof Strait, 1963–1965. Anthropological Papers of the University of Oregon no. 13. Eugene.

Combellick, R.A.
1991 Paleoseismicity of the Cook Inlet Region, Alaska: Evidence from Peat Stratigraphy in Turnagain and Knik Arms. Professional Report 112, Alaska Division of Geological and Geophysical Surveys, Fairbanks.

Crowell, Aron
1996 Field notes, mapping and testing at KEN-324. On file, National Park Service, Alaska Support Office, Anchorage.

Detterman, Robert L., and John K. Hartsock
1966 Geology of the Iniskin–Tuxedni Region, Alaska. U.S. Geological Survey Professional Paper no. 512. U.S. Government Printing Office, Washington, DC.

Dixon, R. Greg
1996 Tiq'atl'ena Bena (Hewitt Lake) Archaeological Research Project, 1992 Investigations. In *Adventures through Time: Readings in the Anthropology of Cook Inlet, Alaska*, pp. 93–107. Edited by Nancy Yaw Davis and William E. Davis. Cook Inlet Historical Society, Anchorage.

Dumond, Don E.
1981 *Archaeology on the Alaska Peninsula: The Naknek Region, 1960–1975*. Anthropological Papers of the University of Oregon no. 21. Eugene.
2001 Toward a (Yet) Newer View of the (Pre)History of the Aleutians. In *Archaeology in the Aleut Zone of Alaska: Some Recent Research*, pp. 289–309. Edited by Don E. Dumond. Anthropological Papers of the University of Oregon no. 58. Eugene.
2005 The Arctic Small Tool Tradition in Southern Alaska. *Alaska Journal of Anthropology* 3(2):67–78.
2011 *Archaeology of the Alaska Peninsula: The Northern Section, Fifty Years Onward*. Anthropological Papers of the University of Oregon no. 70. Eugene.

Esdale, Julie A.
2008 A Current Synthesis of the Northern Archaic. *Arctic Anthropology* 45(2):3–28.

Grantz, Arthur
1956 Magnetite Deposits at Tuxedni Bay, Alaska. U.S. Geological Survey Bulletin 1024-D.

Griffin, Dennis
1989 Report of Investigation for Tuxedni Bay Cave Painting, Cook Inlet Region, Inc. Report on File, BIA–ANCSA Office, Anchorage.

Hausler, Philomena
1991 An Expanded View of the Ocean Bay Period: Preliminary Findings from the KOD-363 Site. Paper presented at the 18th annual meeting, Alaska Anthropological Association, Anchorage.

Henn, Winfield
1978 *Archaeology on the Alaska Peninsula: The Ugashik Drainage, 1973–1975*. Anthropological Papers of the University of Oregon no. 14. Eugene.

Holliday, Vance
2004 *Soils in Archaeological Research*. Oxford University Press, Oxford.

Holmes, Charles E., and J. David McMahan
1996 1994 Archaeological Investigations at the Igiugig Airport Site (ILI-002). Office of History and Archaeology Report no. 57. Alaska Department of Natural Resources, Anchorage.

Holmes, Charles E., Douglas R. Reger, Craig Mishler, Rolfe Buzzell, Douglas Gibson, and J. David McMahan
1985 Progress Report, Project F-021-2(15)/(A09812), Sterling Highway Archaeological Mitigation: Phase 1 Excavations at Four Sites on the Kenai Peninsula. Public Data File 85-04, Alaska Division of Geological and Geophysical Surveys, Anchorage.

Irving, William N.
1957 An Archaeological Survey of the Susitna Valley. *Anthropological Papers of the University of Alaska* 6(1):37–52.

Johnson, J., and Paul Blanche
2012 Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes—Southcentral Region, Effective June 1, 2012. Special Publication no. 12-06. Alaska Department of Fish and Game, Anchorage.

Juhle, Werner
1955 Iliamna Volcano and Its Basement. U.S. Geological Survey, Open File Report 55-77.

Karlstrom, T.N.V.
1964 Quaternary Geology of the Kenai Lowland and Glacial History of the Cook Inlet Region, Alaska. U.S. Geological Survey Professional Paper no.

443. U.S. Government Printing Office, Washington, DC.

Klein, Janet
1999 Abandoned Village, Discovered Histories. Report to the Humanities Forum, Anchorage, and the Chenik Institute, Homer. Manuscript on file, Office of History and Archaeology, Anchorage.

Klingler, Steve
1993 Archaeological Reconnaissance in Lake Clark National Park and Preserve: Chinitna Bay to Tuxedni Bay, Cook Inlet, August 1992. Report on file, National Park Service, Alaska Support Office, Anchorage.

de Laguna, Frederica
1975 *The Archaeology of Cook Inlet*, 2nd ed. Alaska Historical Society, Anchorage.

Miller, Thomas P., and Robert L. Smith
1987 Late Quaternary Caldera-Forming Eruptions in the Eastern Aleutian Arc, Alaska. *Geology* 15:3434–3438.

Reger, Douglas R.
1981 A Model for Culture History in Upper Cook Inlet, Alaska. Unpublished PhD dissertation, Department of Anthropology, Washington State University, Pullman.
1998 Archaeology of the Northern Kenai Peninsula and Upper Cook Inlet. *Arctic Anthropology* 35(1):160–171.

Reger, Douglas R., and Alan Boraas
1996 An Overview of the Radiocarbon Chronology in Cook Inlet Prehistory. In *Adventures through Time: Readings in the Anthropology of Cook Inlet, Alaska*, pp. 157–171. Edited by Nancy Yaw Davis and William E. Davis. Cook Inlet Historical Society, Anchorage.

Reger, Douglas R., and Joan B. Townsend
1982 Norton: A Changing Southeastern Boundary. *Arctic Anthropology* 19(2):93–99.
2004 Prehistory at the Pedro Bay Site (ILI-001), Alaska. Report to the Pedro Bay Village Council and to the U.S. National Park Service Heritage Preservation Program, Anchorage.

Reger, Richard, A. G. Sturmann, E. E. Berg, and P.A.C. Burns
2007 A Guide to the Late Quaternary History of Northern and Western Kenai Peninsula, Alaska. Guidebook 8, Alaska Division of Geological and Geophysical Surveys, Fairbanks.

Riehle, James R., and Karen S. Emmel
1980 Photointerpretation Map of the Surficial Geology, Polly Creek to McArthur River, Cook Inlet, Alaska. Geologic Report 64, Alaska Division of Geological and Geophysical Surveys, Fairbanks.

Riehle, James R., Jurgen Kienle, and Karen S. Emmel
1981 Lahars in Crescent River Valley, Lower Cook Inlet, Alaska. Geologic Report no. 53, Alaska Division of Geological and Geophysical Surveys, Department of Natural Resources, Fairbanks.

Reimer, P. J., M. G. L. Baillie, E. Bard, A. Bayliss, J. W. Beck, P. G. Blackwell, C. Bronk Ramsey, C. E. Buck, G. S. Burr, R.L. Edwards, M. Friedrich, P. M. Grootes, T. P. Guilderson, I. Haidas, T. J. Heaton, A. G. Hogg, K. A. Hughen, K. F. Kaiser, B. Kromer, G. McCormac, S. Manning, R. W. Reimer, A. Richards, J. R. Southon, S. Talamo, C. S. C. Turney, J. van der Plicht, and C. E. Weyhenmeyer
2009 INTCAL09 and MARINE09 Calibration Curves, 1–50,000 Years Cal BP. *Radiocarbon* 51(4):1111–1150.

Rogers, Jason S., Douglas R. Reger, Joshua D. Reuther, Robert C. Bowman, Jill Baxter-McIntosh
2012 Archaeological Site Evaluation at KEN-00324, the Magnetic Island Site, Lake Clark National Park and Preserve, West Cook Inlet, Alaska. Report prepared for U.S. National Park Service, Lake Clark National Park and Preserve, Alaska, by Northern Land Use Research, Inc., Fairbanks.

Schiff, Caleb J., Darrell S. Kaufman, Kristi L. Wallace, and Michael E. Ketterer
2010 An Improved Proximal Tephrochronology for Redoubt Volcano, Alaska. *Journal of Volcanology and Geothermal Research* 193:203–214.

Shaw, Robert D.
1982 The Expansion and Survival of the Norton Tradition on the Yukon–Kuskokwim Delta. *Arctic Anthropology* 19(2):59–73.

Slaughter, Dale C.
2005 Radiocarbon Dating the Arctic Small Tool Tradition in Alaska. *Alaska Journal of Anthropology* 3(2):117–133.

Stanek, Ronald T., James A. Fall, and Davin L. Holen
2006 West Cook Inlet: Ethnographic Overview and Assessment for Lake Clark National Park and Preserve. National Park Service Research/ Resource Management Report NPS/AR/CCR 2007-59.

Steffian, Amy F., and Patrick G. Saltonstall
2005 Tools but Not Toolkits: Traces of the Arctic Small Tool Tradition in the Kodiak Archipelago. *Alaska Journal of Anthropology* 3(2):17–49.

Stuiver, Minze, Paula J. Reimer, and Ron W. Reimer
2005 CALIB 5.0 program and electronic documentation. Online at http://calib.qub.ac.uk/calib/.

Tennessen, David
2006 Results of the 2002–2005 Interior Lakes Survey: Archaeological Prospection in Selected Interior Regions of Lake Clark National Park and Preserve, Alaska. Report on file, National Park Service, Anchorage.

United States Department of Agriculture (USDA)
1993 *Soil Survey Manual*. USDA Handbook 18. Soil Conservation Service, USDA Soil Survey Division, Washington, DC.

Vanderhoek, Richard
2009 The Role of Ecological Barriers in the Development of Cultural Boundaries during the Later Holocene of the Central Alaska Peninsula. Unpublished Ph.D. dissertation, Department of Anthropology, University of Illinois, Urbana-Champaign.

Wilson, Frederic H., Chad P. Hults, Henry R. Schmoll, Peter J. Haeussler, Jeanine M. Schmidt, Lynne A. Yehle, and Keith A. Labay
2009 Preliminary Geologic Map of the Cook Inlet Region, Alaska. U.S. Geological Survey Open File Report 2009-1108. Prepared in cooperation with the Alaska Department of Natural Resources, Division of Oil and Gas, Anchorage.

Workman, William B.
1979 The Significance of Volcanism in the Prehistory of Subarctic Northwest North America. In *Volcanic Activity and Human Ecology*, pp. 339–371. Edited by P. D. Sheets and Donald K. Grayson. Academic Press, New York.
1998 Archaeology of the Southern Kenai Peninsula. *Arctic Anthropology* 35(1):146–159.

Workman, William B., and Peter Zollars
2002 The Dispersal of the Arctic Small Tool Tradition into Southern Alaska: Dates and Data from the Kenai Peninsula, Southcentral Alaska. *Anthropological Papers of the University of Alaska* 2(1):39–49.

Wygal, Brian T., and Ted Goebel
2012 Early Prehistoric Archaeology of the Middle Susitna Valley, Alaska. *Arctic Anthropology* 49(1):45–67.