MAMMOTH TRUMPET

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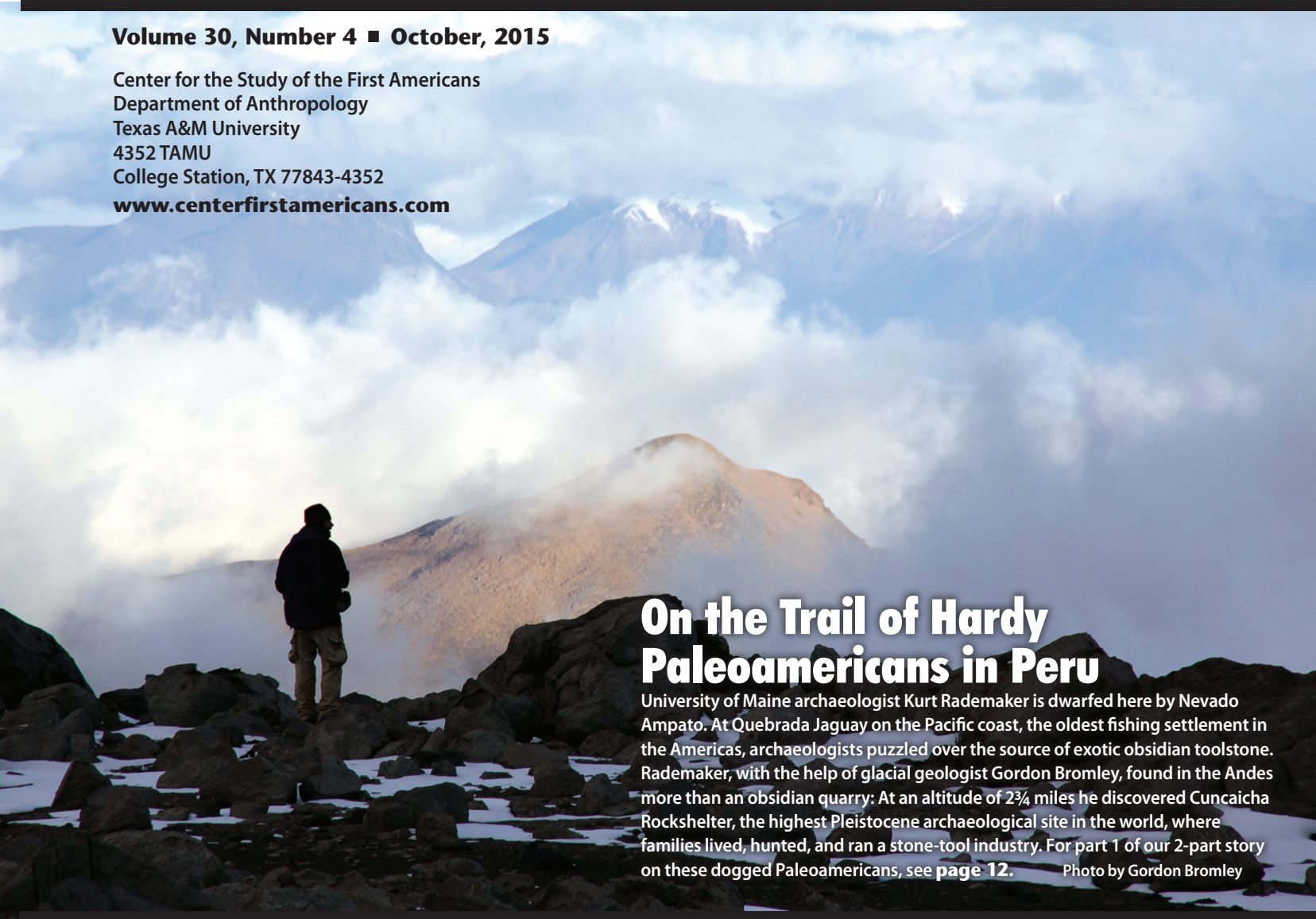

On the Trail of Hardy Paleoamericans in Peru

University of Maine archaeologist Kurt Rademaker is dwarfed here by Nevado Ampato. At Quebrada Jaguay on the Pacific coast, the oldest fishing settlement in the Americas, archaeologists puzzled over the source of exotic obsidian toolstone. Rademaker, with the help of glacial geologist Gordon Bromley, found in the Andes more than an obsidian quarry: At an altitude of 2¾ miles he discovered Cuncaicha Rockshelter, the highest Pleistocene archaeological site in the world, where families lived, hunted, and ran a stone-tool industry. For part 1 of our 2-part story on these dogged Paleoamericans, see **page 12.** Photo by Gordon Bromley

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Looking for Sites at the Water's Edge

QUENTIN MACKIE

McLaren excavating in a small coffer at Kilgii Gwaay.

FOR CANADIAN archaeologist Quentin Mackie, the story begins with an idle thought—and ends with a surprising find that could redraw human history for the coastal Pacific Northwest.

While flying to the 2013 Paleoamerican Odyssey conference in Santa Fe to present a paper on finding submerged archaeological sites, Mackie wondered what sort of sites would be easiest to find. Campsites? Lithic scatters commonly found on dry land? No, he decided, not robust enough to easily locate and photograph on a drowned coastal plain.

Fishing sites came to mind. Some sites he has examined over the years contained fish weirs—large structures designed to corral fish and make them easier to catch. They're big enough to show up on side-scan sonar, a common tool for underwater archaeologists, the University of Victoria associate professor recalled thinking. Even choked with sediment and sticking up only ankle height, there should be a good chance of detecting one with an Automated Underwater Vehicle in deep water. The idea appealed to him, so he went on line to see what types of AUVs were out there. "The first one that came up was a bright yellow one," he recalls. To his amazement, it sported

INSIDE

a UVIC logo. He confesses, "I had no idea my institution had an AUV."

Found, a probable paleo fish trap under 375 ft of water

Returning home after the October 2013 Paleoamerican Odyssey conference in Santa Fe, Mackie contacted the university's Mechanical Engineering department, which had the AUV previously used for finding a shipwreck off Canada's coast. Mackie left a brief message: "You don't know me. I have no money, but I have a great idea. . . ." Surprisingly, Mackie's concept got the green light. Within a couple of months a research project "all fell together." Mackie gives the lion's share of the credit for success to Alison Proctor of the UVIC Mechanical Engineering Department, an expert in AUV work.

"Couldn't have done the work without her!" says Mackie. Funding for the AUV work was provided by the Ronald Ramsay Trust Fund, UVIC Engineering.

The area Mackie planned to explore lay off the southern tip of the archipelago of 138 islands 130 km offshore from the British Columbia mainland formerly known as the Queen Charlotte Islands, now Haida Gwaii. The southern one-third of the archipelago is the Gwaii Haanas National Park Reserve/Haida Heritage site (known simply as Gwaii Haanas), the home of the Haida people for millennia. Detailed sea-floor maps identified hot spots for potential sites along a network of three submerged river channels and tributaries in Juan Perez Sound off Haida Gwaii.

In August 2014, Dr. Proctor at the controls "flew" the 3½-m-long, $1.5 million AUV on an 8-day flight above the sea floor. In flight the AUV surveyed a transect of the sea floor 100 m wide at a resolution of about 50 cm. In all, the team surveyed 125 km of transects and discovered what may be a 13,700-year-old rock-wall fish weir at a depth of about 122 m. That's about 24 m above the Pleistocene low stand of 145 m. If confirmed, possibly this year, it will be the oldest fish weir in the world—pushing back the earliest human occupation in the Canadian Northwest to a startlingly early date and giving a boost to a West Coast route of entry to the Americas, one of several hotly debated theories on how, and when, people first entered the New World.

It's noteworthy that in 1998 Fedje and Josenhans discovered a stone tool on the sea floor 60 m higher and 1 km distant

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–Michael R. Waters, Director

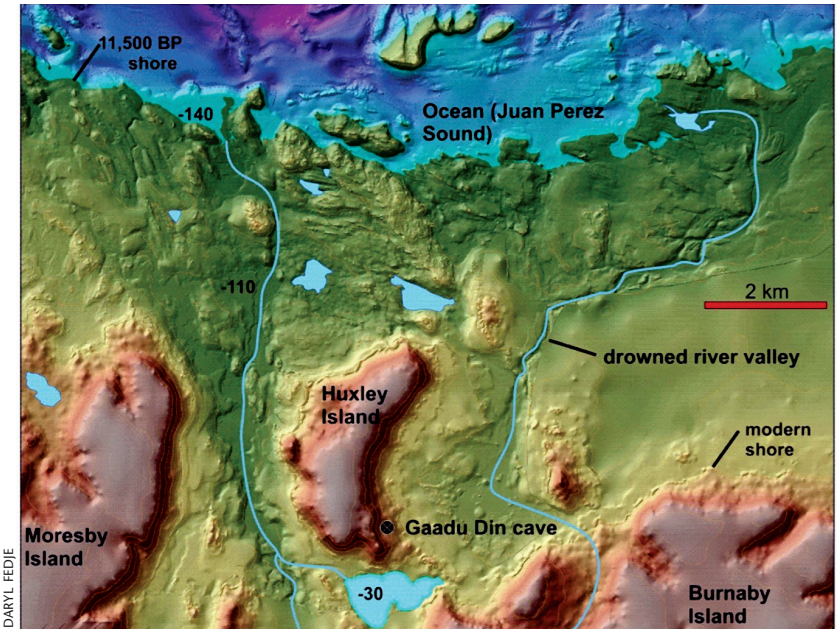
from this probable weir. For Mackie, their study was "a breakthrough and an inspiration."

"We have some very suggestive-looking pictures," Mackie says with cautious excitement. "We have at least one potential stone wall. It's not ideal, but it doesn't look super geological. It's very narrow and at right angles to a small creek, analogous to hundreds of fish weirs we've seen." From the information available today it looks to Mackie like a probable weir. Side-scan pictures from the AUV, unfortunately, lack the resolution needed to confirm cultural features.

DARYL FEDJE

The AUV in the water alongside a launch of the Parks Canada warden.

Based on the team's understanding of sea levels as measured by numerous data points used to establish a baseline for variations in sea level over the years, the weir was last above water about 13,700 years ago—part of a lush landscape that provided a migration route for game animals and people, suggests Mackie. But researchers must verify the find, which Mackie says won't be easy. "It will have survived sea-level rise," he explains, "but probably its original structure has been reorganized a bit over the years." It would be ideal to find wooden stakes associated with it, but he doesn't hold high hopes of finding any other artifacts there. Because of the depth, they need to use a Remotely Operated Vehicle (ROV) to examine and photograph it more clearly. "But just pictures of a potential fish weir aren't going to cut it," he realizes. "We need something unequivocally cultural." A return to the site this year is Mackie's target if he can obtain an ROV (another expensive research tool). He also hopes to take soil samples along the submerged intertidal zone and associated terraces adjacent to the suspected weir.



DARYL FEDJE

High-resolution model of the sea floor showing drowned stream features targeted by the AUV survey.

The prize: proof that boat people colonized the Americas

Although finding the potential fish weir is a definite highlight in Mackie's research, it's just another chapter in ongoing research for Canadian researchers who have been exploring the Gwaii Haanas archipelago for more than two decades with support from Parks Canada, the University of Victoria, the Park Reserve, and the Tula Foundation. By closely studying changes in coastline shapes and sea level over time, analyzing countless numbers of soil cores, and creating detailed sea-floor maps using the latest in sonar technology and computer modeling, Canadian archaeologists are opening new avenues for understanding ancient human activity along the Pacific Northwest coast. Their successes have researchers from Baja Mexico to Alaska focusing renewed energy on finding early submerged sites, the Holy Grail for archaeologists seeking to bolster support for a hypothesized West Coast entry into the Americas.

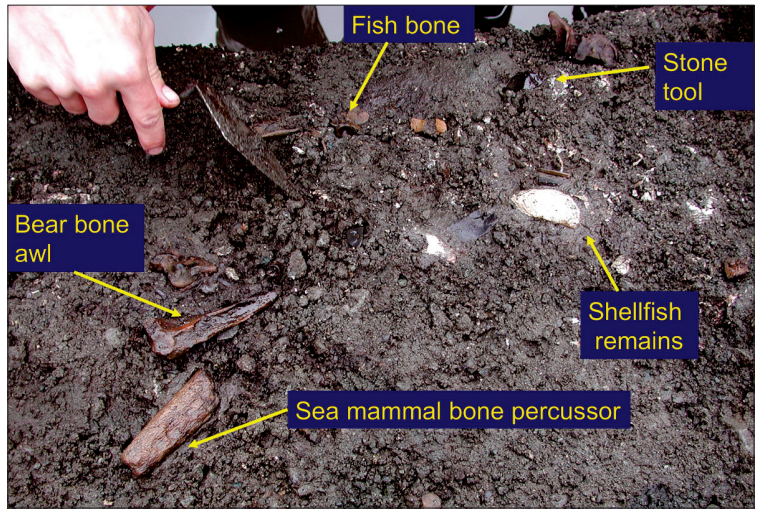
Working in a land of many coastlines are Drs. Mackie, Duncan McLaren, and Daryl Fedje, former archaeologist with Parks Canada and now a part-time assistant professor at UVIC (his footprints appear large across Gwaii Haanas after decades of unraveling its prehistory). Together with their colleagues, they have produced mounds of data and recorded hundreds of sites along the archipelago. Their contributions constitute a singular corpus of literature that illuminates ancient lifeways along the storm-tossed Canadian Pacific Northwest Coast and motivates other archaeologists to seek coastal sites. They also acknowledge work being done by two coauthors farther south, Loren Davis of Oregon State University in Corvallis and Amy Gusick, formerly with the University of California–Santa Barbara and now archaeologist for HDR Inc. in San Diego (**MT 24-3,** "Putting muscle into coastal-entry research").

People at home in a harsh, changing environment

Harvesting a treasure trove of artifacts and evidence from the

Gwaii Haanas archipelago, the research shows a broad mosaic of ancient people hunting bears, fishing, and tapping a wide range of marine resources at the terminal Pleistocene. The fish weir, if verified, would enormously march backward in time the onset of that occupation, says Mackie. He hopes that coastal sites at least 15,000 years old will eventually be found.

At the very least, the breadth of research on the Gwaii Haanas archipelago resolves the uncertainty of a decade ago, when there existed no conclusive evidence of substantial maritime adaptation along the Northwest coast before 5,500 years ago. "There were earlier sites," says Mackie, "but poor preservation made interpretation difficult, and so it was considered unproven whether there was substantial marine resource use before that date."



Some of the contents of in situ deposits at Kilgii Gwaay.

Now a new family portrait of First Americans is emerging. "What we have," Mackie tells us, "is a far more ancient people living large across an enormously challenging landscape, people who seem to have nearly limitless capacity for adaptation and survival."

Contrary to previous views, Mackie is convinced these were a people "comfortable with marine resources at a very early time in a part of the world where the environment is pretty challenging. We aren't talking about nice warm water here. This is cold and turbulent water, and yet people were very comfortable with it as they adapted to what was a dynamic, quickly changing environment."

How the environment changed over time has taken archaeologists years to divine, and the literature suggests that the theory that pictures boatloads of immigrants from Asia paddling down the West Coast into the Americas has a way to go before it is firmly established.

Wooden wedge, direct dated to 10,680 CALYBP. ▶

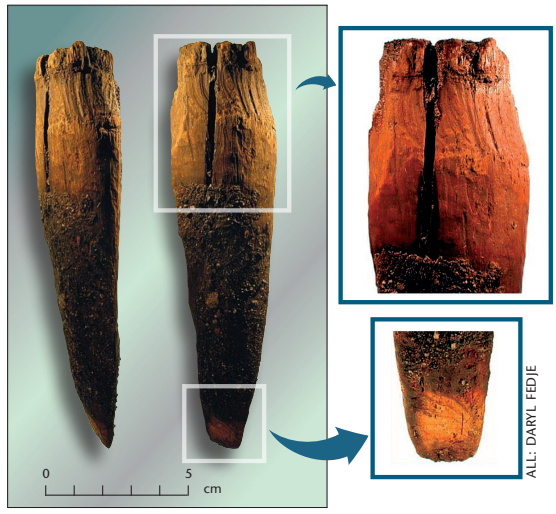
Fragment (1 cm long) of 3-ply braided cord held in hand, 10,700 CALYBP.▼

Canadian archaeologist Knut Fladmark is most often associated with the West Coast–entry hypothesis and the use of boats by people moving south out of Asia into the Americas (**MT 14-1,** "Fladmark, still a coast-route champion, decries archaeology's terrestrial bias"; **MT 15-3,** "Boats or footprints? Archaeologists urged to consider watercraft"). Attempts to investigate his suggested route, however, have been frustrated by evidence drowned under fathoms of water when continental glacial ice melted and raised the sea level. Then there's the storm-tossed Pacific coastline itself, where high-energy waves erode potential sites and chip away at coastlines.

Coping with constantly changing shorelines

Nor are all coastlines the same, cautions Mackie. The Gwaii Haanas terrain, sea-level changes, and occupation sites have been greatly affected by glaciation, which has created a land of many coastlines—a crenulated, irregular landscape with numerous environmental niches that lured human populations since the Pleistocene. Even in the case of fairly regular coastlines farther south, in Oregon and California, for example, many ancient shorelines and near-shoreline sites are deeply submerged and subject to constant ocean turbulence. Without exceptionally detailed ocean-floor mapping, soil analysis, and other expensive hard science and computer modeling, it's easy for archaeologists to become pessimistic about their chances of finding needles in a seemingly mountainous haystack. "Doing hard science, particularly underwater, on a social-science budget is difficult," Mackie admits.

Nevertheless researchers in Oregon and California, coauthors of Mackie's *Paleoamerican Odyssey* paper, are working on it and enjoying limited success. "We don't have anything offshore in state or federal waters as yet," says Dr. Davis. Funded by a federal contract intended to support possible off-shore energy development, he and other researchers are creating highly detailed maps and predictive models for Oregon, Washington, and California along the outer continental shelf to a depth of 135 m, "what we think is the depth of the last glacial maximum." Creating these maps and models has been an experience, like the Pacific Ocean, sometimes turbulent. Computer programs to examine 10-m-square "tiles" of sea floor took eight hours to run because of their detail and complexity, Davis re-



calls. It wasn't long before they overloaded personal computers used to process data. "It actually melted the graphics card on our computer," Davis says with undisguised surprise. "I never thought I could find the limits of a personal computer."

Detailed maps and models show some of the "highest of the highest" possibilities for finding sites. They also paint a portrait of a paleolithic shoreline vastly different, says Davis, from "today's straight, boring coast." Researchers are discovering more streams etched across the ancient landscape than suggested by present shorelines, and numerous ancient estuary systems are also appearing—all magnets for early people. It appears that in the past "there was much more diversification" of landscape, he says.

QUENTIN MACKIE

Fedje working in the 12,500-year-old Gaadu Din Cave 2 site in Gwaii Haanas with student Nicole Smith.

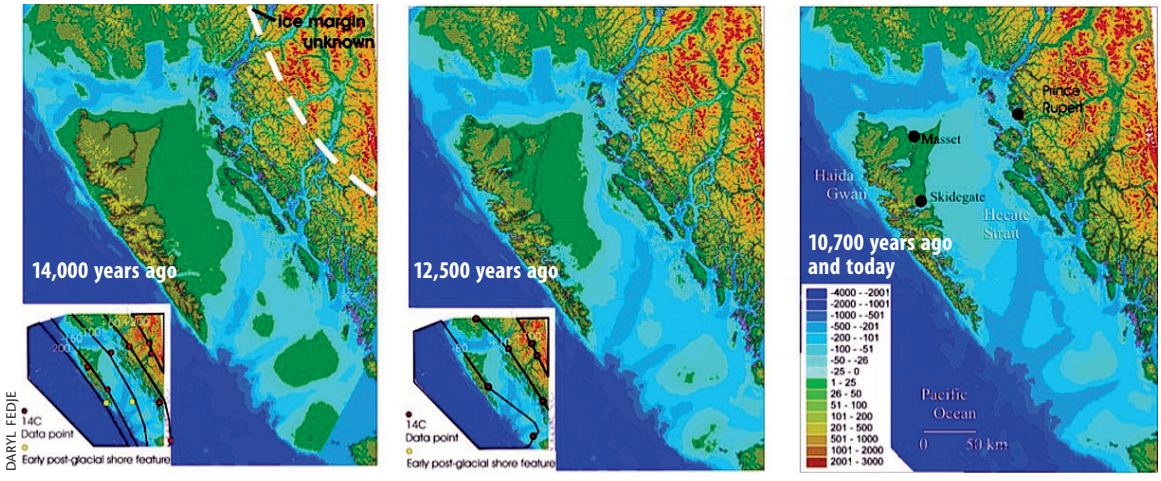
The difficulty and expense required to test the models make for hard-won gains. Nonetheless researchers are sometimes happily surprised. For example, Davis tells of finding extensive submerged ground-based fishing banks off the coast. These low-lying mountains would have been a barrier to the Pacific, and behind that shield are ancient bays and estuaries. One submerged bay in particular on the central coast of Oregon, roughly between Newport and Heceta Head, has caught his interest. "Smaller than San Francisco Bay and bigger than San Diego Bay," he describes it with undisguised excitement. He identifies it as a prime target for further detailed research, possibly with robotic underwater vehicles, once scientists identify the highest probability areas. Discussions are currently underway with National Oceanographic and Atmospheric Administration (NOAA) scientists to conduct underwater archaeological research in the area by underwater drones, possibly in 2016, using sea-floor maps he and other researchers have produced.

Look first for sites on shore

Very old sites found onshore along the Oregon coast are the incentive to test for even older sites offshore. For instance, people lived at the Indian Sands site in Curry County more than 10,400 years ago (**MT 22-1,** "Late Pleistocene Occupations on the Oregon Coast"). The site is endangered, however, by coastal high winds that are deflating the sands above the shoreline and threatening to obliterate evidence of occupation.

Ancient sites also appear farther down the coast in California. The Channel Islands off Santa Barbara hold vast potential for Pleistocene-age finds (**MT 25-4,** "A Story of Ancient Mariners"). Dr. Gusick points out two significant finds: The Arlington Spring skeleton site on Santa Rosa Island near Santa Barbara (**MT 22-1,** "Arlington Springs—the story isn't over yet"; **MT 21-4,** "First lady of the New World: Arlington Springs woman"), a coastal site occupied nearly 13,000 years ago; and work being done by Jon Erlandson at Daisy Cave on San Miguel Island (**MT 26-4,** "A story of ancient mariners"; **MT 13-2,** "Living on the Rim"), which has yielded evidence of cordage use about 10,000 years ago.

Davis and Gusick credit Mackie and his Canadian colleagues with spearheading Pacific coastal research



DARYL FEDJE

Changes to the shoreline of Haida Gwaii with rise in sea level.

by finding and sampling paleolandscapes—much of it, surprisingly, not underwater. The end result is quite impressive: more than 600 sites within Gwaii Haanas alone, which Mackie is confident date to a narrow window around 10,700 CALYBP, when sea level was similar to today. "This is a large sample of Pleistocene sites," he declares, "especially for the Americas."

Mackie cautions that deciding where to look for ancient sites is crucial. A multiplicity of factors—relative sea level, shape of the landscape, and shoreline complexity—affect the "coastal geometry" to be considered. Specialists in geoarchaeology, the marriage of soil science, geology, and archaeology, are indispensable in finding ancient sites on land or under water.

DARYL FEDJE

Mackie *(left)* and student Nicole Smith screening sediments at Gaadu Din Cave 2.

Glaciation is the spanner in the works

Context, in this case geophysical context, is everything. Glaciation looms large in the history of the changing landscape of the Canadian archipelago, including Gwaii Haanas and surrounding territory, for its role in shaping the ancient shoreline and today's shoreline. Shaping results from a complex interaction among forces: isostatic rebound (the rise of ice-depressed ground after glaciers melt), tectonic (normal mountain building) forces, and eustatic forces (sea-level rise). The impact of these forces varies with the contours of the landscape and therefore creates uneven changes in area. Researchers seek the "sweet spot" between extremes for potential sites. It's what Mackie's colleague, Dr. McLaren, calls "the coastal plain which was never drowned," where the complicated mosaic of natural forces balanced each other out and created relatively water free Pleistocene-age sites. McLaren has explored Dundas Island near Prince Rupert, and Hakai to the south, examples of ancient above-water sites on essentially undrowned remnants of paleo-age shorelines close to modern shorelines. Such areas are desirable because they're easily accessible and involve digging on land rather than underwater, although in some cases only for short periods during tidal fluctuations.

Kilgii Gwaay is a stellar example of regional intertidal sites (**MT 24-3,** "Early bear hunting and ceremony on the Northwest Pacific Coast"). In a small south-facing cove on a small island of southernmost Haida Gwaii, about 10,600 years ago a summer camp was occupied that left shell-rich cultural deposits and evidence of other activities. According to Mackie, "It's a fairly large site with a lot of different activity areas and different preservation and site formation processes, even within a single beach." The site was under water until recently. Field work from 2000 to 2012 recovered more than 6,000 lithic artifacts in intact deposits, including distinctive unifacial tools and a few bifacial tools, but no microblades. Mackie credits his colleagues Fedje and McLaren with much of the work done there. Researchers also found bone, wood tools, and hearth material. Remains of marine animals including albatross, seals, sea lions, ling cod, rock-

continued on page 10

Horn Shelter No. 2 Double Burial

America's Earliest Shaman?

In 1970, avocational archaeologists Al Redder and Frank Watt uncovered an extraordinary double burial beneath 2 m of earth in Horn Shelter No. 2 in central Texas. Forty-two years later Smithsonian archaeologist Margaret Jodry and her physical anthropologist colleague Douglas Owsley restudied the remains of the man and young girl buried together here. The results of their analyses appear in the recently published book *Kennewick Man: The Scientific Investigation of an Ancient American Skeleton*. They conclude that the evidence provides an unprecedented opportunity to explore aspects of status and ceremonialism in a Paleoamerican society. They identify the adult male as a medicine man, or healer, based on the artifacts buried with him supplemented by particular aspects of his skeleton. If they're right, a remarkable continuity in beliefs and ceremonial practices extends back from early historic times to the First Americans.

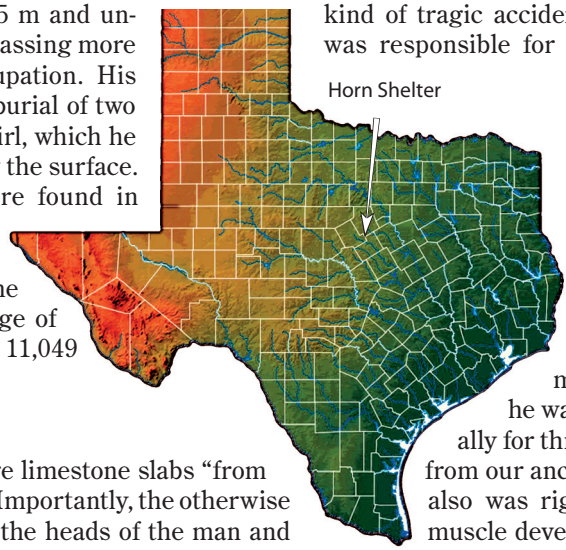
In situ arrangement of items found beneath the man's head.

UNLESS NOTED: PHOTOGRAPHS BY CHIP CLARK, SENIOR SCIENTIFIC PHOTOGRAPHER; DON HURLBERT, JIM DILORETO, AND KRISTEN QUARLES IN THE CENTER FOR SCIENTIFIC IMAGING AND PHOTOGRAPHY FOR ADDITIONAL PHOTOGRAPHY AND DIGITIZATION; SCOTT WHITTAKER, SEM LAB FOR MICROPHOTOGRAPHY.

A shelter on a busy waterway

Horn Shelter No. 2 is a large rockshelter situated at a prominent bend in the Brazos River in central Texas. The Brazos, the longest river in Texas, was a key transportation corridor from Blackwater Draw in New Mexico to the Gulf of Mexico.

Redder began his investigation of Horn Shelter No. 2 in 1966 and continued his explorations for 23 years. Ultimately he excavated to a depth of nearly 5 m and uncovered a series of deposits encompassing more than 13 millennia of human occupation. His most important discovery was the burial of two people, an older man and a young girl, which he encountered at a depth of 2 m below the surface. Although no projectile points were found in the burial, Redder recovered San Patrice points from the same level as the burial. Radiocarbon dates on bone from the burials ranged from an age of 11,158 CALYBP for the adult male to 11,049 CALYBP for the juvenile female.



The double burial

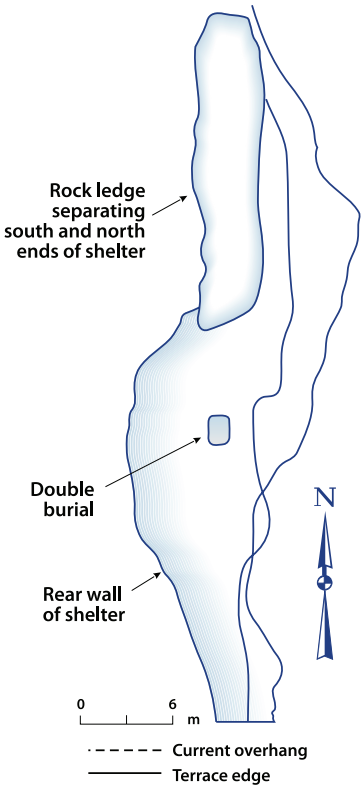
The bodies were covered by 19 large limestone slabs "from the area of their necks to their feet." Importantly, the otherwise continuous pavement of stones left the heads of the man and girl exposed. They were buried on their left sides with their legs pulled up towards their chests in a manner archaeologists refer to as semi-flexed. They faced to the west, toward the back wall of the rockshelter, with the man in front and young girl up against his back. There are no signs of trauma on the bones, but the fact that they are buried together suggests that some kind of tragic accident or unfortunate set of circumstances was responsible for their coincident deaths. One possible interpretation is that the man died for whatever reason and the young girl was ritually killed to accompany him into the afterlife.

The man was between 37 and 44 years of age. He was 5 ft 5 in. tall, of medium build and with strong hands. The muscle attachments on his arm bones indicate he wasn't a hunter. Contrast Kennewick Man, whose right arm was more developed than his left, signifying he was right-handed and used his arm habitually for throwing a spear (**MT 30-1,** "Ambassador from our ancient past"). The Horn Shelter No. 2 man also was right-handed, but rather than exhibiting muscle development characteristic of frequent hunting with a spear, his arm bones showed "diverse muscle use in strenuous, sustained, and repetitive activities."

Jodry and Owsley found that his teeth "show near complete loss of their crowns from attrition" and five had abscesses. The distressing condition of his teeth was "the most life-threatening health risk identified" in the skeleton.

The man was buried with an amazing and revealing trove of 117 objects. According to Jodry and Owsley, his face was covered with a turtle carapace and his "head rested on ten closely grouped items," which included 3 additional turtle carapaces, a probable stylus made from deer bone, 2 pestles made from deer antler, a biface made from Edwards chert, 2 sandstone abraders, and a chunk of red ocher. These clustered objects may have been contained in a leather or cloth bag that has since disintegrated.

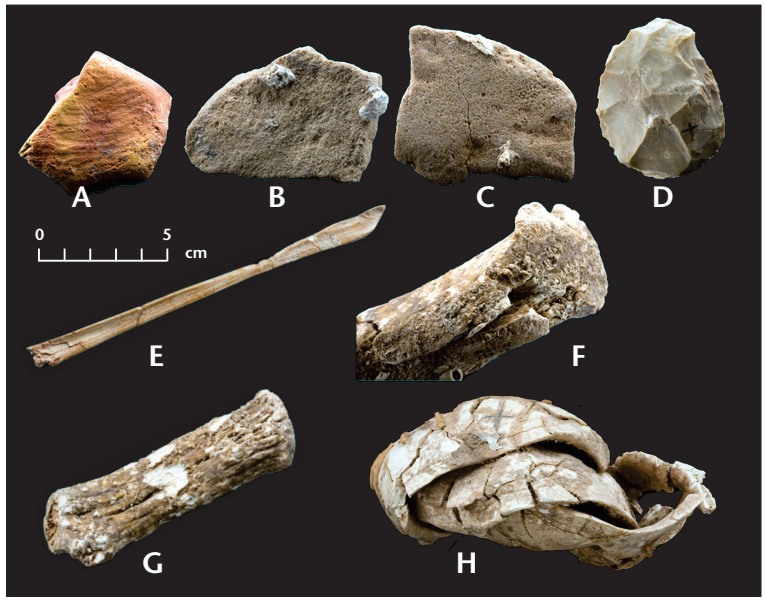
Additional items recovered near the man's head and neck were 4 coyote tooth pendants, 5 badger claws with an additional badger foot bone, 5 talons from a Swainson's hawk associated with 4 additional foot bones, and a shell bead. In all, 83 marine shell beads were recovered from the burial; although most were found near the man's torso, excavating disturbed their original position relative to the bodies. Another turtle-carapace bowl and a deer-antler tool were found beneath the man's pelvis, and a fourth tool of deer antler was found in the area between his right forearm and his leg.



Plan view of the south end of Horn Shelter No. 2 showing relative locations of the double burial, rear wall, and rock ledge.

Tools of the trade

This remarkable assemblage of funerary artifacts suggests to Jodry and Owsley that the man had a special status in his social group. After reviewing the extensive body of research on hunter-gatherer societies, especially those in North America, particularly in Texas, Jodry and Owsley think they have identified the nature of that special status. They suggest he was a "healer, perhaps a medicine man or shaman" and their argument is convincing.



Items from the bundle beneath the man's head, excavated and processed: A, ocher nodule; B–C, tabular pieces of sandstone; D, Edwards chert biface; E, deer-bone tool; F–G, deer-antler tools; H, three nested turtle carapaces.

Jodry and Owsley note the special location and form of the burial. It was situated in the center of one chamber of the rockshelter, and the two bodies had been covered up to their necks by large limestone slabs. This partial covering of stones, suggestive of a turtle's shell, may reflect an intentional effort to make the burial mimic a turtle. The many turtle carapaces associated with the burial confirm the special significance of turtles for this man and his social group.

The 10 items found beneath the man's head suggest a "personal bundle" with artifacts that may have been used to process red pigment for use in body painting or possibly tattooing or ritual scarification. The ocher nodule found beneath the turtle shell bowls had "use-wear markings," suggesting it had been worked by a sandstone abrader. The other had been gouged by some other tool, perhaps the bone stylus. Both sandstone abraders and the bone stylus bore traces of pigment.

The turtle-shell bowls appear to have served as mortars used with the antler pestles to grind the ocher into powder. Two of the shell interiors were stained with hematite residue, and the antler tools have "rounding, polish, and striations" along their ends and sides indicating they were used in "rocking and rotary motions against a curved surface."

Jodry and Owsley quote an early historical source that states that among many Algonquian tribes "the favorite medicine bowl of their doctors is the shell of a turtle." Hematite, the source of the red pigment, also has curative properties and can be used as an antiseptic, so its presence in the burial might relate both to its use as a pigment and as a substance used in healing.

Small flint flakes removed from the biface and a coyote canine tooth with modified tip could have served as scarifiers. Jodry and Owsley observe that scarifying, practiced by indigenous societies worldwide, includes "bloodletting during initiations and other ceremonies, tattooing (both medicinal and decorative), and scratching human skin during healing practices to more effectively apply infusions of medicinal plants." All the other artifacts found with the man, such as the unmodified coyote canine teeth, badger claws, and the Swainson's hawk claws, could be ceremonial accoutrements for a medicine man.

It's difficult to interpret the suite of artifacts associated with the Horn Shelter No. 2 double burial as anything other than the kit of a shaman or medicine man. A close study of the man's bones supports that interpretation. The areas of muscle attachments on his hands and arms resulted not from the thrusting and throwing motions of a hunter, Jodry and Owsley tell us. More likely they developed from sustained shamanic drumming "undertaken repetitively over many years" using a "handheld frame drum and beater." Moreover, Jodry and Owsley conclude from the particularly well developed muscles of the man's right thumb and forefinger that "he made repeated use of a precision grip," perhaps in performing "repetitive healing tasks including body painting."

Shell beads and two of the four perforated coyote teeth. Most of these items were recovered near the man's head, neck, and torso.

Why were they paired in death?

Although the skeleton of the juvenile female wasn't as well preserved as the male's, nonetheless it reveals that she was 10 or 11 years old at death. Like the male's, her bones don't reveal an obvious cause of death. The only artifacts found directly associated with her were a broken bone needle and a few beads that may have been originally associated with the man before being displaced in excavation.

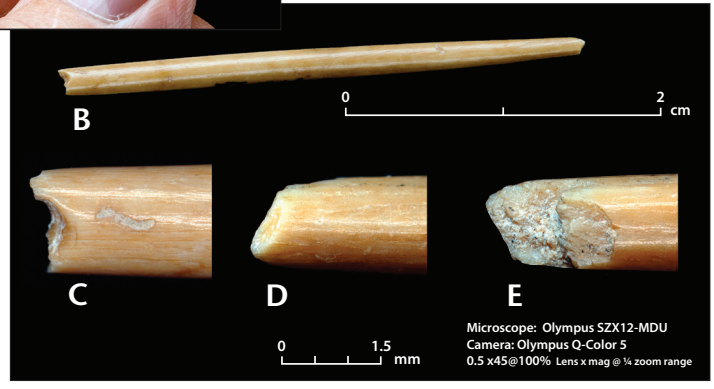
There clearly is a compelling story behind this double burial. What was the relationship between these two people? In an article in the *Waco Tribune-Herald,* Redder supposes that the child may have been sacrificed to accompany the shaman in death, though he acknowledges that "we'll never know for sure." In an interview in the same newspaper article, Jodry notes that the girl's bones bear no evidence that she had been intentionally killed. In fact, for Jodry the archaeological record is disappointingly silent about the girl's life and death.

The girl's bones give no evidence that she may have been sacrificed to accompany the shaman. Ethnographic accounts of Inuit people cite instances where young daughters were killed upon the death of a male head of a household. On the other hand, burials of juveniles with elaborate mortuary offerings, such as the Anzick infant (**MT 29-2,** "Clovis child answers fundamental questions about the First Americans") suggest Paleoamerican children typically were highly valued. Is it possible the man and girl died together? Such a scenario may not be as unlikely as it first appears.

Perhaps the young girl was gravely ill and this middle-aged shaman, himself unwell, was overcome while attempting to cure her. We know that some forms of indigenous healing practices required substantial physical exertions by the practitioners. For example, according to anthropologist Richard Lee traditional healers among the Kalahari San people burn as many calories during a single healing ceremony as they might consume in an entire waking day. It may be that the healer expired from his labors and was buried with his kit beside his patient. Besides serving as healers, shamans also acted as guides who led the souls of recently deceased to the spirit world. In this case, the shaman may have personally accompanied his young patient all the way to that "undiscovered country from whose bourne no traveler returns."

A Paleoamerican shaman?

The Horn Shelter No. 2 double burial is significant for many reasons. Perhaps its most important contribution is the window it opens onto the ceremonial lives of Paleoamericans. Jodry and Owsley argue compellingly that the man was a medicine person, or healer—not just a part-time practitioner as was typical of many egalitarian hunting and gathering societies, but a dedicated specialist. His bones show that he did not spend much time hunting, but instead was primarily devoted to ceremonial activities. It's therefore likely that the community supported him in return for his services as a healer and ceremonial leader. Finding this level of occupational specialization at such an early period is surprising.



Eyed bone needle found with young girl. **A,** held in fingers; **B,** side view of the smoothed and polished exterior; **C,** encircling striations within the perforation; **D–E,** opposite sides of green-bone fracture on the needle tip.

Jodry and Owsley conclude that the various animals

represented in the suite of artifacts associated with the shaman's burial "likely served as markers of clan and other social affiliations and as spiritual amulets connecting the man with tutelary animals, ancestors, elements, and/or places." They note that the "social and spiritual are intertwined in traditional society."

The five turtle carapaces associated with the burial, and the turtle effigy suggested by the rock slabs covering the burial, underscore the prominent place occupied by the turtle in the cosmology of historically documented and contemporary Northeastern Woodland peoples. Indeed, many of these groups refer to North America as Turtle Island. The Horn Shelter Burial No. 2 may have been Turtle Island since the beginning—or at least for the last 11,000 years. MT

–Brad Lepper

BERNIE DUTON

Jodry with items from Horn Shelter 2.

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Suggested Readings

Jodry, M. A., and D. W. Owsley 2014 A new look at the double burial from Horn Shelter No. 2. In *Kennewick Man: the scientific investigation of a an ancient American skeleton,* edited by Douglas W. Owsley and Richard L. Jantz, pp. 549–604. Texas A&M University Press, College Station.

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Looking for Sites at the Water's Edge

continued from page 6

fish, and halibut are compelling evidence for Mackie that these ancient people were proficient at living off the sea and had boats. As we might expect of scientists, however, not all researchers agree that early people would have been comfortable in a Northwest marine environment or would have risked travel by boat in the cold north Pacific Ocean (**MT 15-2,** "First Americans probably were not marine specialists, scientist argues").

According to the paper of Mackie et al., "Kilgii Gwaay appears to be a summertime base camp for logistically organized people who routinely used watercraft and employed a variety of organic technologies in pursuit of their fully maritime adaptation." Prior to 11,000 years ago, it was likely a freshwater pond in a remote saddle valley in Haida Gwaii's interior. But the landscape didn't remain static. As the sea level rose, the occupants constantly abandoned campsites as the landscape was drowned. Mackie emphasizes that "Kilgii and the 140 intertidal sites are, literally, underwater sites that have been re-exposed after 10,000 years of being up to 15 m below modern sea level." Understanding how people moved across a changing environment is crucial to finding sites, Mackie tells us. Variables that account for the likelihood of campsite relocation must be factored into predictive models if sites are to be found and interpreted.

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McLaren, D., D. Fedje, M. B. Hay, Q. Mackie, I. J. Walker, D. H. Shugar, J. B. R. Eamer, O. Lian, and C. Neudorf in press A post-glacial sea level hinge on the central Pacific coast of Canada. *Quaternary Science Reviews* (2014), http://www.sciencedirect.com/science/article/pii/S0277379114002042

Onshore sites are an attainable goal

Although Mackie hasn't abandoned hope of finding submerged sites to bolster the West Coast–entry hypothesis, he emphasizes the need to keep looking for above-water sites. "The underwater stuff is interesting, sexy," he admits, "but the best chance of finding sites is going to be with tried-and-true archaeological methods on land. Find something, dig it up carefully—traditional solid archaeology." Indeed, in recent years tantalizing sites have been found in the West that appear to be of pre-Clovis age: The Manis Mastodon site in a marshy area on Washington's Olympic Peninsula, at nearly 14,000 years old (**MT 28-2,** "The Manis Mastodon in context"); Ayer Pond on Orcas Island at 13,900 years old (**MT 26-3,** "Pre-Clovis butchers of *Bison antiquus*"); and Paisley Caves in central Oregon, with its possible 14,200-year-old human coprolites and Western Stemmed projectile points topping 13,000 years old (**MT 28-2,** "The Western Stemmed Tradition points from Paisley Caves: Older than Clovis"; **MT 25-4, 26-1,** "Paisley Caves"). These sites promise a shining potential for coastal research. But look above the sea first, Mackie emphasizes, and pinpoint suspected submerged sites so the huge sums of money it takes to test them will be well spent. After decades of Canadian research, Mackie is convinced that an early entry to the Americas along the Pacific Coast is more than a possibility. It's clear to him that "these people had boats, particularly around Haida Gwaii, which is as remote as it gets."

When researchers set about making detailed maps and predictive models for finding potential sites, they must be careful, he counsels, not to sell Paleoamericans short. "We shouldn't limit our ideas of what these people were capable of," he says. "They appear to have had few limitations. Rather than thinking what could these people have done, we should be thinking, What couldn't they have done? I think that is going to help with building models and eventually finding more stuff." MT

–George Wisner

QUENTIN MACKIE

Fedje and UVic grad student Jenny Cohen screening sediments at Kilgii Gwaay.

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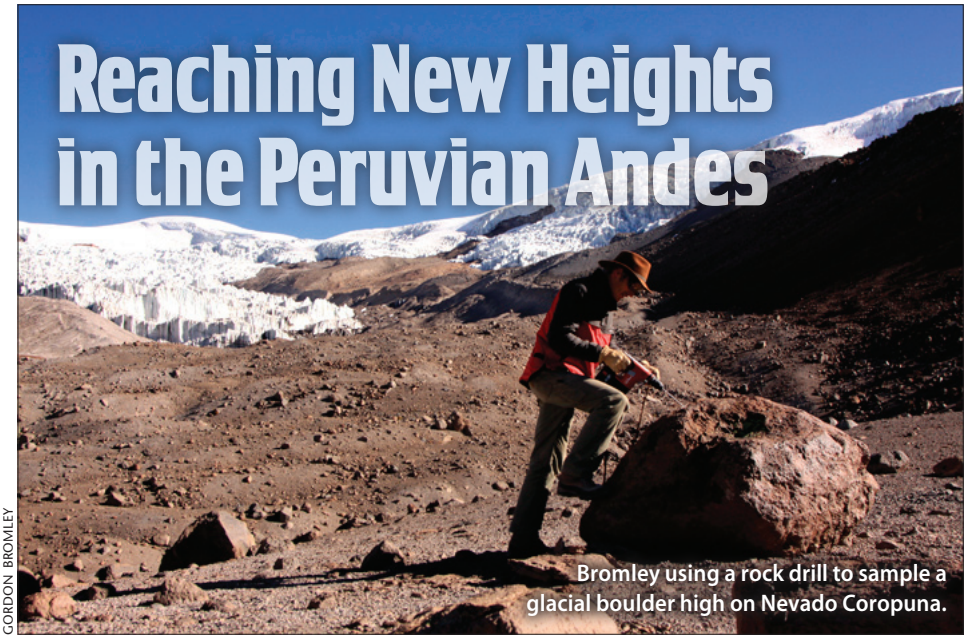
DUNCAN MCLAREN

Mackie *(left)* and Fedje at their "public interpretation coffee bar" when working at the Richardson Island site in Gwaii Haanas. Says Mackie, "We rolled the poster up and down when kayakers came by."

Reaching New Heights in the Peruvian Andes



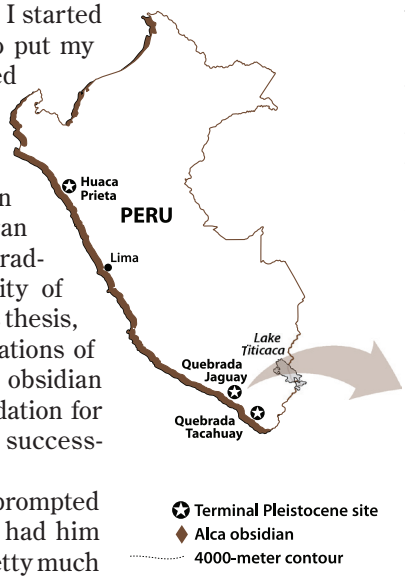
GORDON BROMLEY

Bromley using a rock drill to sample a glacial boulder high on Nevado Coropuna.

Part I

WHEN KURT RADEMAKER stumbled upon what would be known as the Cuncaicha Rockshelter high in the Andes mountains, he had no idea it would turn out to be the highest Pleistocene archaeological site yet discovered in the world. "It was only when I started reading up on other sites to put my study in context that I realized that's actually what I had," Rademaker says.

The postdoctoral researcher, based at Tübingen University in Germany, began his work in Peru during graduate school at the University of Maine at Orono. His master's thesis, "Geoarchaeological investigations of the Wayñuna site and Alca obsidian source, Peru," laid the foundation for his dissertation, which he successfully defended in 2012.



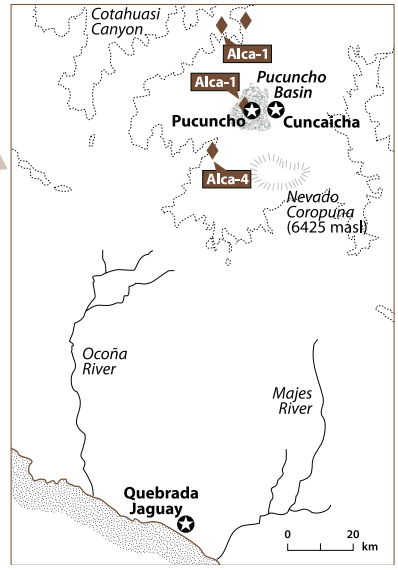
Rademaker's discovery prompted tons of media coverage and had him on "skype or on the phone pretty much for a week straight" when he first arrived in Germany. "Having the work published in *Science* is gratifying," he says, "but having the work spread around the world through various media outlets was great because we could share what we learned with a much larger audience."

Quebrada Jaguay

Several events led to the discovery, all starting with another archaeological site called Quebrada Jaguay. Daniel Sandweiss, professor of Anthropology and Quaternary and Climate Studies at University of Maine at Orono and Rademaker's doctoral advisor, excavated the site in the '90s and thereby planted the seed for Rademaker's research years later (**MT 20-4, 21-2,** "Early maritime adaptations in western South America"). Rademaker describes Quebrada Jaguay as "the oldest fishing settlement in the Americas. It's a site on the Pacific coast, at the mouth of this canyon that comes down from the Andes mountains." The site, a residential base camp, is shell midden, trash heaps of clam shells and fish bones. In addition to the shell midden, Quebrada Jaguay contains some of the earliest house structures known in the Americas and evidence of stone toolmaking. "Almost all the animal remains at the site are from Pacific Ocean species, indicating a specialized coastal adaptation," says Rademaker.

Sandweiss's team found that drum fish and surf clams made up the majority of faunal remains at Quebrada Jaguay. They also found seeds of prickly pear cactus, which is significant because, as Rademaker explains, prickly pear doesn't grow along the coast; it grows in the Sierra. Although this site is clearly an example of marine adaptation, there was evidence that these people living coastally had some connection with the interior, with the Andes mountains.

What's more, there was a handful of obsidian—volcanic glass—which suggested something else was going on. "Obsidian comes from the Andes," says Rademaker. "So if you have this little fishing site, then what the heck is this obsidian doing there?" Often one question begets many more: Did these people who lived along the coast come from the mountains? And if so, did they learn to fish? Or did they get this obsidian from trading with a different group that came from the mountains? To answer these questions, Rademaker found he had to locate the origins of the obsidian itself. "That started a decade of work for me," he says, "the idea that I could go to the highlands, find this obsidian source, and look in the vicinity of this obsidian source to find an early site and then learn something about the peopling of South America."



Locating the obsidian source

"The location of the 'Alca' obsidian," Rademaker says, "was

first reported by a cultural anthropologist named Paul Trawick, who was studying indigenous irrigation systems in the Cotahuasi Valley. A local resident of the town of Alca brought Paul a big block of obsidian, and Paul showed it to Yale archaeologist Richard Burger, who at the time was searching for Peruvian obsidian sources to understand prehispanic exchange networks. Richard and his colleagues geochemically analyzed the Alca obsidian and found it was a match for the obsidian of artifacts found at early coastal site Quebrada Jaguay."

KURT RADEMAKER

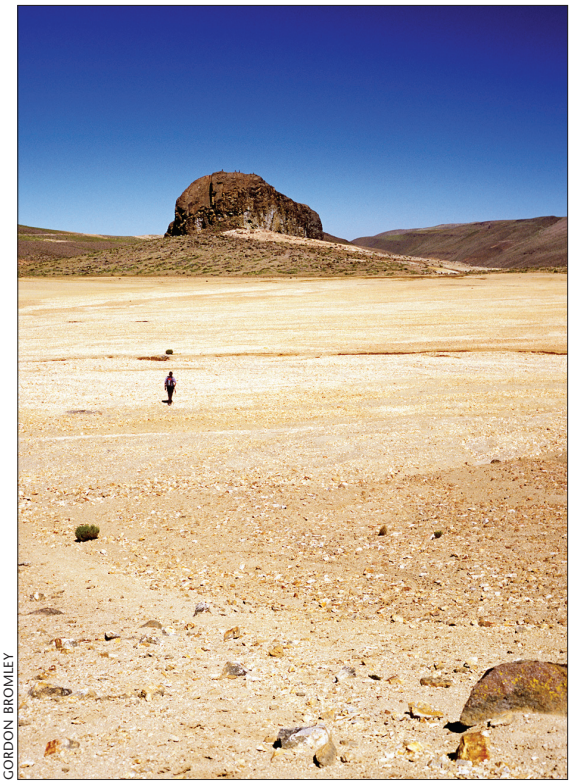
Elizabeth Olson and Christopher Miller excavating in Cuncaicha rockshelter, 2012.

Rademaker, working from Richard Burger's initial survey of the Cotahuasi Valley, mapped the full extent of the Alca obsidian source in the surrounding area and studied its chemistry in a systematic way. Rademaker's team showed that the Alca obsidian source is much larger than previously thought and that most of the source is found on the high-elevation plateau. "Almost all the Alca obsidian source—and it's one of the biggest in South America—was above 4000 meters above sea level [m.a.s.l.]," Rademaker explains.

He set out to explore the highlands on foot, hoping to find early sites comparable to Quebrada Jaguay. "First I mapped the entire obsidian source," he says, "and while I was doing that I was also looking for early sites." He recalls that "it took years of looking, finding hundreds of sites. I'd document sites no matter what age they were, but after covering enough ground, it became obvious which sites were the real targets." Because the region he was exploring was vast and ecologically complex, he used Geographic Information Systems (GIS) least-cost analysis to evaluate possible forager routes—paths of least topographic resistance—that connect Quebrada Jaguay with Alca obsidian outcrops. Apart from the east rim of the Cotahuasi Canyon, the largest concentrations of obsidian were found in the Pucuncho Basin. He found that Alca outcrops in the high-elevation Pucuncho Basin at 4500 m.a.s.l. were easier to get to than the ones in the Cotahuasi Canyon, even though the canyon was much lower in elevation." Moreover, the Pucuncho Basin was a shorter distance from Quebrada Jaguay. That finding led to Rademaker's discovery of Cuncaicha—which occupies one side of the Pucuncho Basin—and other early sites in the highlands.

The environment of human settlement

As Rademaker mapped the obsidian at higher elevations, he started finding glacial landforms, which triggered the involvement of his colleague, glacial geologist Gordon Bromley. Although Rademaker could identify the glacial landforms thanks to his training at the Climate Change Institute at the University of Maine, he needed an expert to help him understand the landscape. This partnership made the project truly interdisciplinary. Rademaker explains, "During our first field season in 2005, Bromley realized we were looking at an area fantastic for studying glaciers and the way they've changed through time, which is a great way of understanding how climate changes over time." Bromley did his Ph.D. research in the same geographical area; he studied the glaciers and their history while Rademaker immersed himself in the archaeology. "We could write grants together and team up on field seasons," Rademaker recalls. "We'd stay in the same camps and just help each other out. We worked through our Ph.D.s sort of side by side, and in the end what we learned was not just when humans settled the high Peruvian Andes, but what the environment was like when they did it."



GORDON BROMLEY

Exploring a glacial valley of Coropuna, last covered by ice during the Ice Age.

Bromley built a high-resolution glacial chronology—mapping glacier extents over time by studying the landforms—and Rademaker compiled a high-resolution archaeological chronology at Cuncaicha rockshelter. The two could be compared directly because they occupied the same spatial parameters. "It was already starting to warm up at the end

of the last Ice Age; ice was beginning to retreat." The original thinking was that early Americans wouldn't even want to live in the high Andes, that it would be covered in ice and way too cold, but Rademaker and Bromley show evidence for early human occupation in a Peruvian climate not much colder or icier than today. Rademaker wonders, "Did the people know it was warming up and then go up there, or was it sort of fortuitous? I don't know the answer to that."

KURT RADEMAKER

Cuncaicha rockshelter.

A system of settlements

One theory is that the early Americans followed migratory animals that may have sensed a shift in the environment. Humans may also have migrated between lower and higher elevations. Quebrada Jaguay, for instance, contains a few materials that come from the highlands. Most of the materials found at Quebrada Jaguary and Cuncaicha are local, however, which we would expect in base-camp settings. These sites aren't isolated; they're part of a system of settlements. To understand how the system functioned, Rademaker wants to identify and investigate sites of similar age in the intervening area to examine how they were connected. That can illuminate the process of human movement from one zone to another, whether that movement was year-round or seasonal, or whether different groups separated by a great distance met somewhere between their ranges.

"We're working at a landscape scale," Rademaker explains, "and what we're seeing is that different Paleoindian sites, with completely different kinds of adaptations (hunters in the highlands, or fishers at the coast) were linked over great distances. Now we're trying to understand those links, how those people are related to one another across a big landscape. There must have been enough people out on the landscape to know about each other and know how to connect the Andes to the Pacific coast."

The advantage of investigating highland sites like Cuncaicha is that they are remarkably intact. Rademaker notes that in the cold, dry setting of the highlands there's little sedimentation to erode or bury sites. Furthermore, local inhabitants are extremely protective of these sites and treasure hunters in Peru normally pick easier, more accessible sites. Nevertheless many people live in the river valleys today, farming and irrigating, and building sites are being developed at a rapid pace, so trying to locate archaeological sites before they disappear is a race against time.

GORDON BROMLEY

Claire Todd of Pacific Lutheran University sampling a glacial boulder for dating surface exposure.

Excavating at Cuncaicha

Not every site preserves the materials that indicate a rich cultural life, but some of Rademaker's sites show the kinds of activities that were happening and who was involved. Rademaker found many stone tools at Cuncaicha, including knives, projectile points, and scrapers used to work animal hides and make warm clothing. "We suspect that making clothing out of hides, probably vicuña [*Vicugna vicugna mensalis*], guanaco [*Lama guanaco*] or deer [*Hippocamelus antisensis*], was a necessary activity," he says. "The alpaca was domesticated from the vicuña, and although alpaca is incredibly soft and fine relative to sheep's wool, vicuña wool makes alpaca wool look coarse. In this very cold place there are animals that have very warm wool, so early people living here would have made clothing out of the local animals."

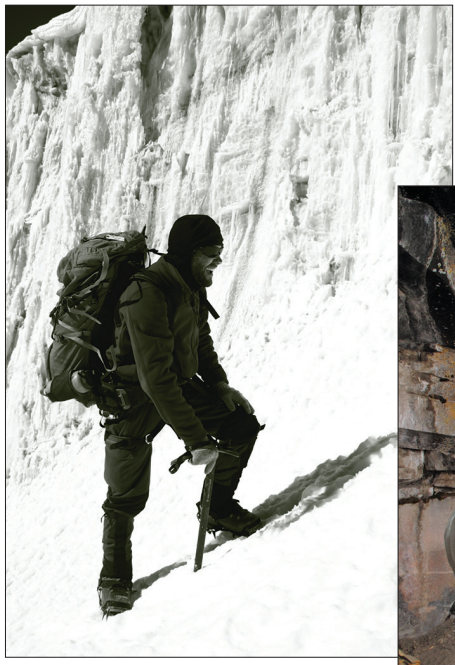
Given its location in the heart of a plateau, its sooted ceilings, rock art, and anthropogenic floor sediments, Cuncaicha doubtless served as a base camp where families lived together. Abundant evidence confirms that entire animals were processed and consumed on site, and stone tools made from start to finish. "The site is too far from lower elevations for it to have been a grab-and-dash kind of place," Rademaker tells us. Based on his excavations into the stratified sediments of the shelter, and radiocarbon dates obtained from camelid bones associated with artifacts recovered from the rockshelter deposits, Rademaker has determined that the shelter was occupied as early as 12,500 years ago, making Cuncaicha, at 4480 m.a.s.l., the highest Pleistocene archaeological site in the world.

"They were able to live in the most challenging environments you can think of—the high Andes at the end of the Ice Age, up

GORDON BROMLEY

Rademaker *(left)* and a University of Maine student following a paved section of Inca road toward the Nevado Coropuna ice cap.

there at 4500 meters—and they were doing just fine," he says. Some tools were made of beautiful stone and purposely shaped to showcase interesting features. So these tools had practical and aesthetic and perhaps symbolic value. One of the goals of their continued work, Rademaker says of his team, is "to understand the culture of these late–Ice Age people as best we can. These were sophisticated people who were capable of living in challenging places, so they definitely had art—we hope it is preserved for us to find."



GORDON BROMLEY

◀ Rademaker approaching the highest geologic site of the project on the slopes of Nevado Coropuna.

▼ David Reid with a projectile point in Cuncaicha rockshelter.

KURT RADEMAKER

Ancient peoples also took the time to create rock art at Cuncaicha, pictographs of camelids and other designs. "I would love to think the rock art was created by the late-Pleistocene occupants of the rockshelter," Rademaker says, "but the problem is that rock art is notoriously difficult to date in sites where there is more than one episode of occupation. Cuncaicha rockshelter was used repeatedly throughout the last 12,000 years. So who made the rock art, and when? Unfortunately, we don't know yet." The rock art is an intriguing facet of high Andean culture, but Rademaker can't yet attribute it to the earliest settlers.

Exploring cultural memory

A single dirt road leads to and crosses the high plateau on its way to the Cotahuasi Valley. In the remote stretches of the Pucuncho Basin roam communities of herders, each comprising around 50 to 100 people, with great herds of alpacas and llamas. Until last year there was no electricity. "They're still carrying out this amazing indigenous way of life," Rademaker says. Many parts of the Andes are experiencing modernization, but in this region there are still traditional animals and very few sheep and cows compared with other areas in the Andes. The people live in stone houses that have been inhabited for millennia.

Cuncaicha is a Quechua word meaning throat or neck. Rademaker says that he and others working in South America use local names for places partly because they can't come up with more interesting names than the locals do. "We like to name sites after the local place name," he says. In a way, this choice endows the local culture with honor and ties it up with cultural memory. The locals speak Quechua, the indigenous language, and Spanish. Andean people are proud of their country's civilizations. "They're interested in what we're doing," Rademaker says, "and a lot of times they'll go up to the sites and just stay there all day watching, sometimes participating. They're always interested in it because they're very proud of it. We tell them, 'You're living in a place where some of the first Andean people lived.' This basin has been used by people—first for hunting, now herding. In this one place is a tremendous 12,000-year sequence of cultural development. It's a very special place for that reason."

Because it's a special place for both the world of archaeology and the locals living there, Rademaker hopes one day to nominate the region as a UNESCO world heritage site, but he notes that "the people have to be behind it, and part of it." Locals have expressed interest in building a local museum, but the Ministry of Culture must give their full consent before plans move forward.

Next comes genetic analysis

"We are using Monte Verde as the earliest accepted low-elevation site of South America," Rademaker explains, "to suggest that Cuncaicha was occupied within 2,000 years of initial settlement of South America. There are claims for even earlier settlement of South America from other sites, but these are contested." That humans established long-term occupations at such extreme altitudes just 2,000 years after entering South America raises questions about genetic adaptation: Did these people possess a genetic adaptation that made it possible for them to flourish in such high altitudes? Did adaptations occur before or after human settlement in such environments? Rademaker hopes to find answers in the near future. The discovery that people prospered at this high altitude so early suggests to him interesting possibilities, either that genetic adaptation to high elevation evolved extremely rapidly, within 2,000 years, or that genetic adaptation wasn't needed for the initial colonization at high elevations and evolved later. "It may be that humans simply have the physiologic capacity to live this high," he says, "and the genetic adaptations in modern Tibetan and Andean people may have arisen relatively recently." Plotting a timeline for genetic adaptation in highland people around the world, a task that requires collaboration between archaeologists and geneticists, will contribute towards our collective understanding of human evolution.

ERICA COOPER

Paleoindian artifacts from the Pucuncho Basin, Peru.

Challenge meets reward

In spite of the need to acclimate anew to high altitude with every field trip, Rademaker craves working in the Peruvian Andes from year to year. For him it's a dream project. "I love the mountains," he confesses. "I love archaeological survey work, looking for new sites." All told, he has spent more than a year of his life camping out in the Andes, braving all the elements, and says of the experience, "I've never been anywhere so peaceful in my entire life." Through this decade-long project he has learned of huge expanses of Peru that haven't been studied archaeologically. Exploring for him is addictive because everything he discovers is new and contributes new knowledge. This project has enriched his life and that of others as well. "Building a team of people—including students—to work on these problems has been really satisfying," he tells us, "because when you build an interdisciplinary team you get multiple perspectives and expertise. Together you can come up with novel ways of learning about the past."

–Katy Dycus

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Suggested Readings

Bromley, G. R. M., B. L. Hall, K. M. Rademaker, C. E. Todd, and A. E. Racovteanu 2011 Late Pleistocene snowline fluctuations at Nevado Coropuna (15°S), southern Peruvian Andes. *Journal of Quaternary Science* 26(3) 305–17.

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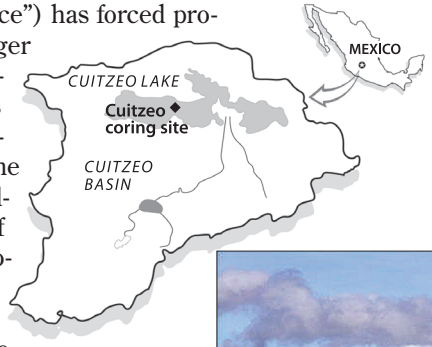
Rademaker, K., G. Hodgins, K. Moore, S. Zarrillo, C. Miller, G. R. M. Bromley, P. Leach, D. A. Reid, W. Yépez Álvarez, and D. H. Sandweiss 2014 Paleoindian settlement of the high-altitude Peruvian Andes. *Science* 346:466–69.

THE CLOVIS COMET

New Developments in the Proxy Evidence, Part III

ABOUT 12,800 YEARS AGO, just as the last Ice Age was ending, a millennium-long cold spell called the Younger Dryas Interval suddenly gripped the Northern Hemisphere. Although researchers have proposed several triggers for the climatic reversal, none felt the need for an extraterrestrial explanation—until 2007, when a cadre of 27 scientists in numerous disciplines proposed, in the Proceedings of the National Academy of Science (*PNAS*), that the YD was triggered by massive cosmic airbursts or impacts.

But absence of impact craters (**MT 29-3,** "The Clovis Comet: The Cratering Evidence") has forced proponents of the Younger Dryas Impact Hypothesis (YDIH) to focus on indirect proxy evidence derived from the Younger Dryas boundary (YDB) strata of archaeological and geological sites. Most of this proxy evidence is microscopic. Some has since succumbed to challenges from other scientists, though at this time nine lines of evidence still have vigorous defenders. In two previous articles, we've examined six proxies (**MT 30-1, -2,** "The Clovis Comet: New Developments in the Proxy Evidence, Part I and Part II"). In this article, we'll consider the last three on our list: nanodiamonds, silica-rich microspherules, and scoria-like objects (SLOs).



AFTER ISABEL ISRADE-ALCÁNTARA

Tiny gems

At one point, nanodiamonds—literally, nano-scale diamonds so small hundreds can hide in a handful of soil—seemed the most unshakable of the YDIH proxy evidence. As far as we knew, nanodiamonds could be created naturally only through the extraordinary heat and pressure delivered by a cosmic impact or explosion. But in 2011 geologists Nicholas Pinter and Andrew Scott, along with physicist Tyrone Daulton, announced that at least some of the reported nanodiamonds were actually other, misidentified materials—usually graphane/graphene oxide aggregates. These carbon-based particles form naturally in terrestrial sediments.

Meanwhile, other researchers saw no need to account for nanodiamonds through cosmic impacts at all. They proposed nanodiamond formation in microscopic "carbon onions," tiny pressure chambers that might yield nanodiamonds in temperatures as low as 450° C. Some YDIH sites containing nanodiamonds have also yielded carbon onions and their fragments. Furthermore, it now appears that some nanodiamonds can form in relatively low-temperature candle and natural gas flames.

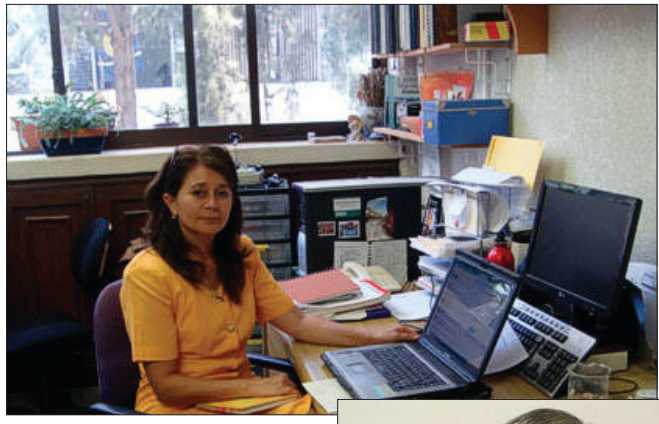
But YDIH proponents—some of whom are microscopists and geologists themselves—continue to present nanodiamond evidence from localities in the Americas, Greenland, and Europe. They mostly reject the misidentification claims, pointing to x-ray diffraction patterns that have detected, among other things, the lattice spacing of several types of microscopic diamonds in their samples.


ISABEL ISRADE-ALCÁNTARA

Lake Cuitzeo.

Some critics have suggested that nanodiamonds come from the "cosmic rain," the kilotons of meteoric dust Earth sweeps up daily. And yes, they've been found in both meteorites and

interplanetary dust. But if nanodiamonds were components of cosmic rain, they should be distributed evenly, in very small amounts, throughout all deposits at all sites. Published data, however, show they're tightly concentrated in YDB deposits. For example, at Sheriden Cave in Ohio, nanodiamonds are present at a level of 400 parts per billion in the YDB—and only in the YDB. Scientists have found nanodiamonds at many other sites with dated YDB strata as well, for example, in the Black Mat at Murray Springs, Arizona, and in the Usselo and Allerød horizons of the same age in Belgium. At Lake Cuitzeo in Mexico, nanodiamonds peak at 100 ppb in the YDB section of a 27-m-long lake-bottom core.



ISABEL ISRADE-ALCÁNTARA

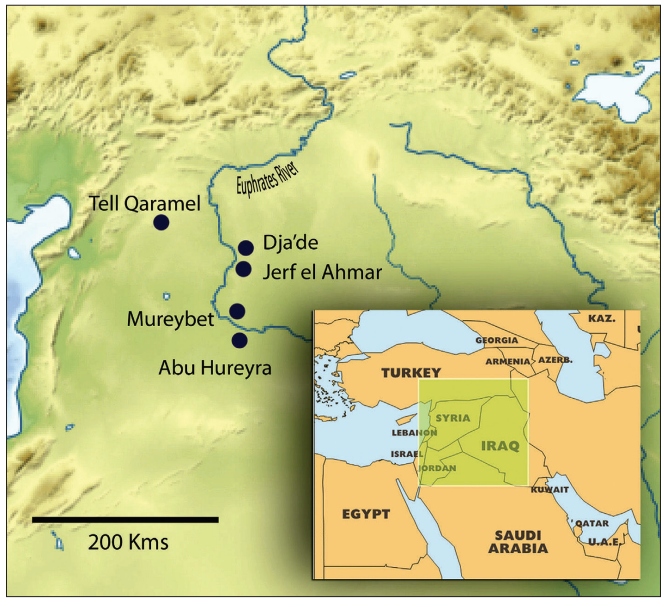
Israde-Alcántara and Bischoff.

"The idea to study long-core records in Mexico started in 1944," explains Isabel Israde-Alcántara of the Institute of Earth Sciences (INICIT) at Universidad Michoacana de San Nicolas de Hidalgo in Morelia, Michoacán, Mexico. "In 1990, Cuitzeo and Chapala, the biggest lakes in Mexico, were not yet drilled. With a project of the Coordinación de Investigación Científica at Universidad Michoacana de San Nicolas de Hidalgo, Victor Hugo Garduño and I started this research to contribute to the understanding of the evolution of paleoclimates and paleoenvironmental records and processes in the central west sector of Mexico, and its further correlation with other cores at regional, interhemispheric, and global scales."

According to James Bischoff of the U.S. Geological Survey, a senior author (along with Dr. Israde-Alcántara) of the *PNAS* paper describing the Lake Cuitzeo findings in 2012, "What first focused our attention on that part of the core (2.7–2.8 m down) was that the radiocarbon dates were anomalous, and way off the linear trend of dates above and below the zone. Extrapolating the linear trend across this zone suggested a date close to the YDB." As for criticisms that the YDB was estimated using statistical methods rather than chronologically pinpointed, Israde-Alcántara explains that "it is standard procedure these days to use statistics to generate age-depth models for lakes. It is also common to have dates that are out-of-order in tectonic lakes."

"As a skeptic of the impact idea," Dr. Bischoff notes, "I had considered it a long shot that putative YDB proxies would be found . . . [but] the diamonds were found, and in greater abundance than elsewhere. We had stumbled on an unusual and unique event horizon. . . . It seemed to me it had to be the same event found at other sites." Might some of the nanodiamonds come from carbon onions? Interestingly, some actually did, according to Israde-Alcántara. "Using a transmission electron microscope, we occasionally have observed nanodiamonds at the cores of carbon onions found in YDB sediment, but not above or below." She observes that carbon onions containing nanodiamonds have otherwise never been found in nature—but can be produced in the laboratory at high temperatures in oxygen-free environments. Forest fires require copious oxygen; cosmic impacts capable of producing nanodiamonds and carbon onions do not.

Meanwhile, YDIH proponents continue to record and publish on the presence of nanodiamonds in YDB sediments. To the unbiased eye, nanodiamonds appear to be the best evidence for a cosmic cause of the Younger Dryas. This could change, however, if other researchers confirm other natural means by which they might be formed. The carbon onion hypothesis is a contender, but remains too poorly understood and described to dismiss nanodiamonds just yet.

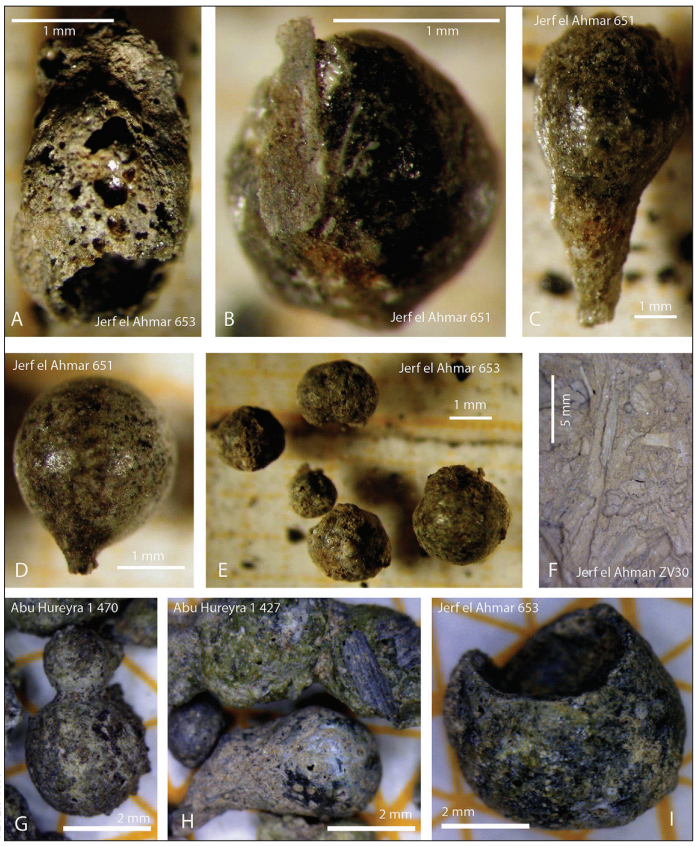


PETER THY ISABEL ISRADE-ALCÁNTARA

Location of five archaeological sites in Syria sampled by Thy et al.

Silica-rich microspherules

Several types of microspherules are routinely extracted from YDB sediments. Previously, we've discussed the phenomena of metallic and carbon microspherules; in this article, we'll consider those rich in silicon. These tiny droplets have been found by YDIH proponents at sites in North America, Europe, and the Middle East. According to a 2012 publication by Ted Bunch et al. in *PNAS*, "Very high-temperature impact melt products as evidence for cosmic airbursts and impacts 12,900 years ago," silica-rich spherules often coincide with peaks of iron-rich microspherules in the YDB layers, with low



PETER THY

Scoria droplets from archaeological sites in Syria, including Abu Hureya (H). The Abu Hureya droplets include several straw ash fragments, indicating their origin.

frequencies in layers above and below. Most are microscopic and tend to be highly reflective or black. Interestingly, their surfaces often show dendritic patterns, indicative of rapid quenching after high-temperature formation.

According to Bunch et al., the textures and morphologies of these objects correspond with silica-rich spherules from known cosmic impact sites—including Meteor Crater, Chicxulub (the dinosaur-killer), and the 1908 Tunguska airburst. Chemical examination shows that >90% of the silica spherules examined are chemically distinct from normal cosmic spherules, which disarms the most common argument against them. YDIH proponents have concluded that, like nanodiamonds, they were created under conditions of high heat and a level of destruction consistent with cosmic impact/airburst events.

The magnetic microspherules isolated from YDB sediments have drawn fire for being difficult to isolate from sediments collected by critics and neutral researchers. Yet despite their importance to the YDIH argument, critics have largely ignored the silica-rich microspherules except to suggest they're part of the cosmic rain. This doesn't, however, explain their chemical content or why they're concentrated in YDB sediments.

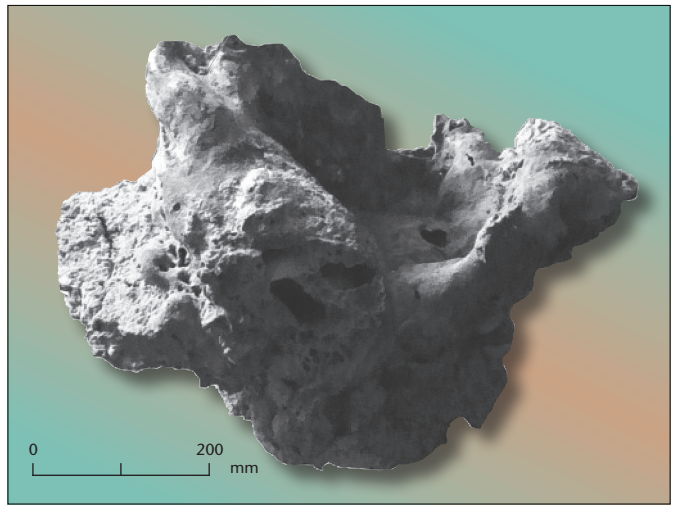
It's worth noting that many of the spherical and semi-spherical scoria droplets examined at five Syrian sites by Thy et al. (see the next section) highly resemble the smaller silica-rich microspherules YDIH proponents have presented as evidence of a YD impact. The significance of this will become clear in a moment.

Scoria-like objects

Silicon-rich scoria-like objects (SLOs) have recently become a significant part of the YDIH argument because they occur in YDB strata on several continents and seem to be the right age. In geological terms, scoria is a silica-rich igneous rock or slag with a "frothy" texture, obviously formed in an environment of high heat; some industrial smelting processes requiring high heat also produce similar scoria as slag. In their 2012 *PNAS* article, Bunch et al. took a close look at the SLOs in YDB strata at three sites, one each in Syria, Pennsylvania, and South Carolina. Their SLOs are irregular to spherical glassy, vesicular siliceous objects chemically very like silicon microspherules. According to Bunch et al., they closely resemble material

recovered from meteor impact craters and the Trinity A-Bomb test site in New Mexico.

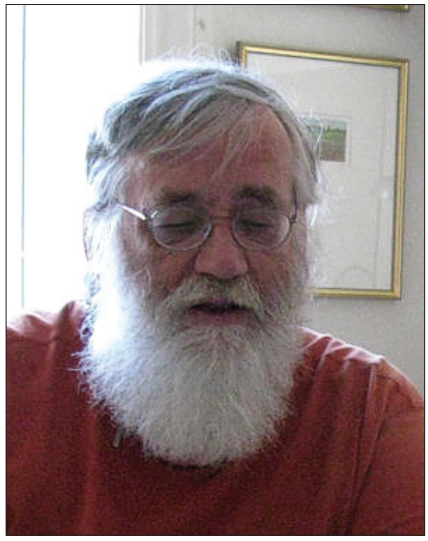
Early in 2015, however, the *Journal of Archaeological Science* published a paper titled "Anthropogenic origin of siliceous scoria droplets from Pleistocene and Holocene archaeological sites in northern Syria," with University of California, Davis, planetary scientist Peter Thy as lead author. Thy et al. examined scoria from Abu Hureyra, the site previously examined by Bunch et al., and four sites with human occupations dating to 11,300–10,500 RCYBP. The samples were collected from levels dated from approximately 10,200–13,200 years ago, a period of 3,000 years. The scoria deposits were localized, and Thy and his colleagues ultimately concluded that all were the results of human activities. They occur in contexts where high-heat burning took place, including the burning of certain types of structures.



PETER THY

Scoria-like building earth fragment from Mureybet, Syria, with visible vesicles and melting features.

Thy specializes in crystallizing and melting in synthetic and natural silicate systems, including ash and slag formation from biomass like straw and wood. He notes that his team collected and examined the larger SLOs, greater than 1 mm in size, because smaller particles would have passed through their water-flotation screens. He reports that careful microscopic examination of these particles revealed textures, mineralogies, and compositions consistent with partial and incomplete melting at modest to high temperatures, mostly below 1200°C. According to Thy, the study also revealed that the composition was similar to the local soil; no mineralogical evidence was found for high-pressure formation. Thy doesn't deny the possibility that some scoria claimed by the YDIH proponents may in fact be evidence of an impact. "All we said in our paper," he notes, "is that the scoria droplets at the Syrian sites aren't related to a narrow stratigraphic interval around the Younger Dryas, and thus cannot be related to any type of impact. They're best attributed to an anthropogenic origin, and are not part of a global fall-out field from a distant impact. . . . It is clear that silicate particles exist at many of the [YDIH] sites, some of which may be scoria droplets similar in origin to those we reported."


K.H. ESBENSEN

Thy.

Scoria can form naturally from subsurface burning of coal seams, as well as from spontaneous combustion of large masses of organic materials. Burning of wooden structures, especially those with straw roofs, may also produce scoria. Indeed, some of the Abu Hureya scoria droplets studied by Thy et al. clearly include fibrous straw ash fragments.

Future considerations

The YDIH has been repeatedly challenged since its original proposal. Some of its critics see no need for it when simpler explanations for the YDI already exist. Others believe it's draining resources from more important research questions. A few have presented their data against it and now refuse to participate in further debate. Some YDIH critics no longer trust the samples provided and analyzed by the laboratories of the chief proponents.

In other words, the YDIH has been treated pretty much like every other controversial hypothesis ever challenged by science. It shows no sign of fading away soon, if only because highly regarded researchers in several scientific fields still champion it—and some crucial questions still need firm answers. The origins of nanodiamonds and silica-rich microspherules, and just how common SLOs are outside the Middle East in non-YDB contexts, are among those questions. We'll continue to watch the YDIH story as it develops and update you as new evidence comes to light or older evidence bites the dust—as the case may be.

–Floyd Largent

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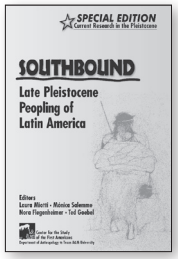

Southbound: Late Pleistocene Peopling of Latin America, Laura Miotti, Monica Salemme, Nora Flegenheimer, and Ted Goebel, editors. 36 articles discussing the late-Pleistocene archaeology and Paleoecology of South America. 2010. 218 pages. Paperback ISSN 8755-898X.

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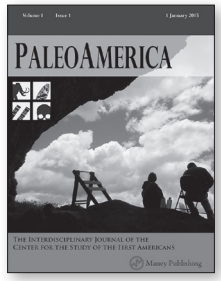

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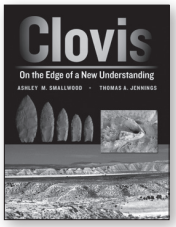

Clovis: On the Edge of a New Understanding, Ashley M. Smallwood and Thomas A. Jennings, editors. 2014. 376 pages. Hardback or e-book (ISBN 978-1-62349-201-4).
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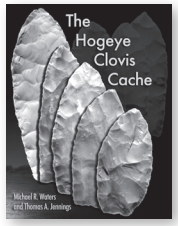

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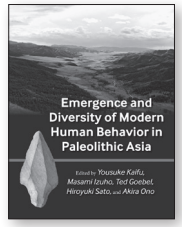

Emergence and Diversity of Modern Human Behavior in Paleolithic Asia, Yousuke Kaifu, Masami Izuho, Ted Goebel, Hiroyuki Sato, and Akira Ono. 2014. 230 pages/ Hardback (ISBN 978-1-62349-276-2).
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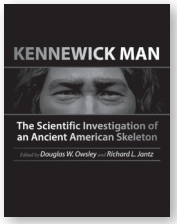

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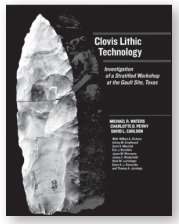

Clovis Lithic Technology: Investigation of a Stratified Workshop at the Gault Site, Texas, Michael R. Waters, Charlotte D. Pevny, and David L. Carlson. 2011. 224 pages. Hardback or e-book (ISBN 978-1-60344-278-7). Reg. price $45.00
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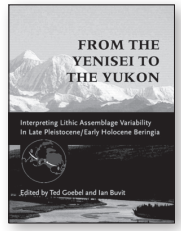

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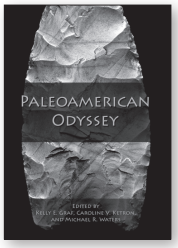

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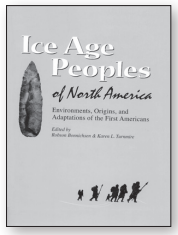

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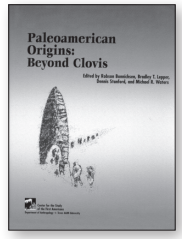

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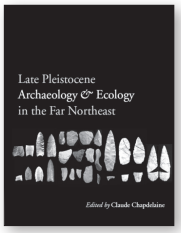

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